R H JORDAN
75 Queens Rd
WALTHAM CROSS

COLE'S CYCLOPEDIA OF MECHANICAL HANDICRAFTS AND INDUSTRIAL PROCESSES.

By M. COLE.

VOLUME 1.

CONTAINING THE FIRST 25 SECTIONS.

Each Section complete in itself, and published separately under the title of "Cole's Reliable Handbooks."

SIXTH EDITION.

1915.

MANCHESTER:

M. COLE, 42, NORTHEN GROVE, WEST DIDSBURY.

TOOLS AND MATERIALS FOR EVERY DESCRIPTION OF
MECHANICAL WORK supplied by
M. COLE, 42, Northen Grove, West Didsbury, Manchester.

When writing for prices please give exact requirements.

BOOKS ON ALL MECHANICAL AND TECHNICAL SUBJECTS.

CONTENTS.

Section.

1. WELDING & FORGiNG, and other Blacksmith's work.
2. BRASS FOUNDING. Moulding in Sand, &c. Core Making. How to Build a Small Furnace. Aluminium Founding.
3. PATTERN MAKING for Brass and Iron Founding.
4. HOW TO SOLDER Gold, Silver, Aluminium, Brass, Tin, Joints in Lead Gas Pipes, Brazing.
5. METAL RIVETTING (Hot and Cold) from Jewellery to Steam Boilers.
6. HOW TO GRIND AND SET EDGE TOOLS from a Razor to an Axe.
7. METAL PIPE AND TUBE BENDING. Cycle Tubes, Brass and Iron Gas and Steam Piping.
8. TEMPERING STEEL TOOLS. Annealing and Case Hardening Iron and Steel.
9. METAL SCREWING with stocks and dies, screw-plates, and taps, making and tempering dies, plates, and taps.
10. METAL DRILLING, Drill Making, Tempering, Grinding, and Using.
11. METAL SURFACE FINISHING. Chipping with chisels, filing, draw-filing, polishing, figuring, burnishing, lacquering.
12. TINPLATE WORKING with Hand Tools, and Sheet Metal Working.
13. WIPED JOINTS in Lead Water Pipes, and Soldered Joints in Lead Gas Pipes.
14. PATENTS FOR INVENTIONS and Registration of Designs. The Law clearly explained.
15. ELECTRIC BELLS, with full instructions for making and fitting Electric Bells, Batteries, &c.
16. THE SAW AND HOW TO USE IT on Wood and Metal. How to Sharpen and Set Saws. How to Braze Band Saws.
17. FRENCH POLISHING and the Use of Stains and Varnishes, with recipes for Polish, Varnish, and Stains.
18. CYCLE BRAZING.
19. CYCLE ENAMELLING. Oven building, varnish receipts, &c.
20. PNEUMATIC TYRE REPAIRING. Instructions for all Repairs—workshop or roadside.
21. MENDING AND REPAIRING Wood, Metal, Glass, Leather, &c,, with many useful recipes for cement, &c.
22. RUBBER STAMP MAKING, STENCIL CUTTING AND WINDOW TICKET WRITING.
23. BOOKBINDING without Special Tools. Instructions for Bookbinding and Gold Lettering.
24. PICTURE FRAMING, MOUNT CUTTING, RE-GILDING, &c.
25. HOW TO CLEAN A CLOCK.

COPYRIGHT

BLACKSMITH'S WORK.

Forging & Welding.

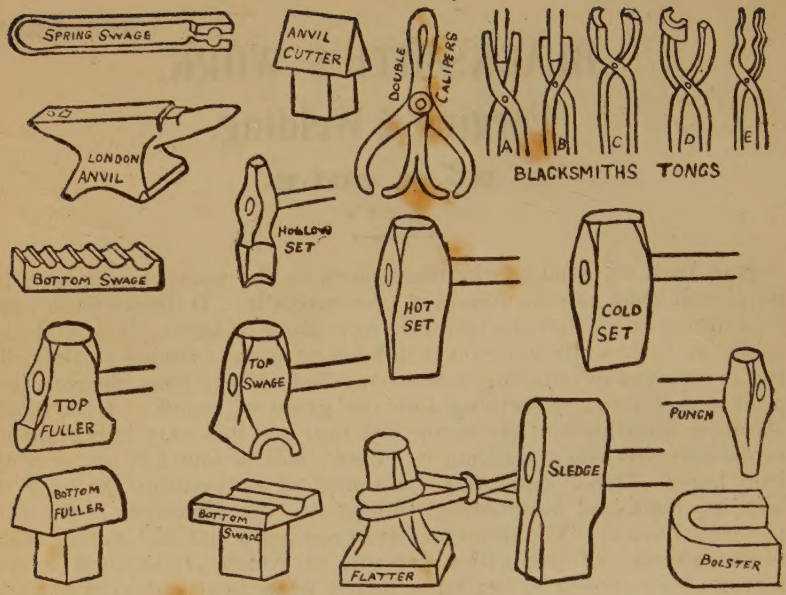
By M. COLE.

* * * *

Bar Iron as used by the blacksmith is the nearest approach to pure iron that can be obtained commercially. It differs from cast iron and steel in that the latter contain more or less carbon, and are easily melted, while bar iron is difficult to melt. Owing to the rolling it receives in reducing it from puddled balls to bars, the iron has a fibrous texture something like the grain of wood. It is much stronger lengthwise than across the bar, and it is very important to remember this when working it. Flaws will be found in low quality iron bars. These can often be remedied by heating the part to welding heat and hammering, though it is often cheaper in the end to throw it away. The difference between good and bad iron or steel is the amount of impurities present, of which phosphorus is the worst. Iron should be heated to nearly white heat and worked until it offers too much resistance to the hammer, which will be a dull red heat. When at the correct heat for working, it offers the same resistance as lead. It is advisable to practice with lead before commencing to work hot iron. Bar Iron is of many sizes and by selecting stock of suitable section a great saving of labour is effected besides producing better work.

Fuel. Charcoal is the best of all fuels for iron working, but is too expensive to use in England. Small coke, *breeze*, made for the purpose is generally used, but any good quality of coal will do, provided it is free from sulphur. If coal is used, it should be partly burned before the fire is used for iron, as soon as it no longer gives a light it is ready and should be kept at a bright red. Any blue flame is a sign of sulphur. The fire must be kept clean, and clinkers and burned out cinders removed. Carefully avoid zinc, brass or lead in the fire if any welding has to be done, or for any important work. The usual forge with bellows, &c. is required for large work, but small work can be heated in an ordinary kitchen fire, if a sheet iron blower plate is used to get a draft.

Heat the work thoroughly and evenly, and do not re-heat too frequently, or the fibre of the iron is destroyed and the iron is *burned.* This can be to some extent remedied by heating and hammering well all over till it is a dull red. Do not hammer iron after it has lost color or it will become brittle. Allow forgings to cool gradually, do not quench. All metals have what is known as a *critical heat,* and are rotten if worked at that heat. In steel this is *blue heat,* in iron *black heat.* The best quality of steel would be spoiled if worked at blue heat. A good deal of *scale* (a form of rust) forms on the iron when heated, this should be scraped or knocked off or otherwise removed. This is particularly necessary before welding.



The principal tools used are :—**Anvil, Hammers, Tongs, Fullers and Swages, Punch and Bolster.**

Hammers. The sledge is usually 10 to 12 lbs., the hand hammer which should have a ball pene at back, ½ to 1-lb. If working without a sledge, a 3 or 4-lb. hammer to use in its place. Before the introduction of the steam hammer, work too big for the sledge was shaped with a suspended hammer or dolly. It consisted of a head fixed to a long shaft of wood or iron, and hung from overhead by a chain. It was used against the side of the anvil, and the larger ones required several men to swing them. They are seldom seen now.

Tongs are usually made by the smith, and are endless in the variety of the shapes of their jaws, so as to be able to grip work of any shape. They are often provided with a ring, which by sliding it as near the jaws as it will go, cause the tongs to grip the work when the hand is removed. A (in above diagrams) shows shape of jaws that cannot grip the work firmly, B another pair having a good hold.

Sets are really chisels fitted with handles. For hot work the set is of lighter section than for cold.

The **Callipers** shown have two movable jaws so as to get two sizes without re-adjustment. The handle should be long as they are used on red-hot iron.

Swages are hollow faced tools having a groove in the face. The bottom swage is fitted in a hole in the anvil, the top swage is held by a handle, the work between them is forced to take the shape of the pair of grooves so that a number of these are required. To reduce the number of tools, the bottom swage is often made with

several grooves, either as shown in diagram, or round the edges of a heavy block, solid enough to be used without an anvil. For single handed work the spring swage is useful.

Fullers are the reverse of swages, and used the same way. A Flatter is a flat faced tool similar to a fuller, and produces a more even surface than could be obtained with hammer work.

Punch and Bolster are for punching holes in hot iron of any thickness, but are also used for punching thin metal cold, for this purpose they must be flat ended. For hot work the punch for starting the hole should be pointed so that no metal is removed, but only pushed aside. It is driven half-way through the work, which is then reversed. A dark spot shows where the hole has been started in the other side and is a guide for placing the punch. The bolster is to raise the work above the anvil face, but if punching is done over one of the holes it is not needed.

Drifts are round or square pieces of steel, a little thicker in the middle than at the ends, so that when forced through the work past the thickest part they fall through. Unless this is done they will remain in the hole. They must be used quickly enough to avoid getting them too hot. They often require a little dressing with the hammer to keep them in condition for effective use.

Handles for these are of three sorts. Where expense is no object, they are shafted or handled like hammers, but as few smiths care to spend so much extra labour they are usually handled by twisting a green hazel or willow rod twice round the tool in a groove provided for the purpose and clipped near the head with a ring of thin rod. The part bent should be well soaked in water, then heated thoroughly and twisted to make it more pliable. Another way is to use $\frac{1}{4}$ in. rod instead of the hazel rods. It is put on hot and the loose ends welded together and set about 1 in. apart, so as to give a hold for the hand.

Anvil Sets are without handles, made to fit the hole in anvil and are useful for single handed work. The bar to be cut is in this case struck instead of the set. All Tools struck with the hammer will burr up at the head, and should be trimmed up as often as required, as the frequent blows make the metal brittle and fragments fly off in a very dangerous manner if neglected.

The Hammer, when in use, should be moved so as always to strike one place as far as possible in the middle of the anvil, and the work moved about, otherwise there is danger of striking the work beyond where it is supported by the anvil which would probably cause an accident. This is even more necessary in using the sledge.

Cutting off a length. If single handed, put the anvil cutter on anvil, lay the bar on it keeping it level, and strike a smart blow with hand hammer, turn the rod quarter round and repeat until it is nicked in all round. See that the cutter is kept sharp, as the sharpness of the edge of the cut is more important than its depth. When deep enough, hold the rod against the outer edge of the anvil and give a smart blow with hammer a little beyond the nick. The shock rather than the force of the blow breaks it off, speed is more important than force in this case.

Upsetting or Jumping. For this the iron should be at a white or welding heat. If for the end of the bar, keep the heat local as far as possible, and bring the hot end down smartly on the anvil (Fig. 11, page 6). Two or three times are usually enough. If this cannot be done on account of the shape, the hammer must be used. If making a swelling in the middle of the bar, the proceeding is the same, heating the part that has to be done.

Drawing down is the reverse of upsetting, for this also a welding heat is required. To begin the Fullers are used, and the job completed with the Flatter (Fig. 12, page 6) or it can be started with the pene of the hand hammer. The work is re-heated as often as required. There is a limit to the quantity of metal that can be displaced either by drawing down or upsetting. When more metal is required in any place than can be got there by these means it is necessary to weld on more metal. It is a good rule never to weld when it can be avoided. The fork shown on page 6 (fig. 6) is a good example of what can be done without welding. The smaller the work, the less satisfactory the welded joints are. The real art of the smith consists of pushing superfluous metal from one part of the bar where it is not required, to another part where it is wanted. When there is the choice between drawing down a bar that is too thick and upsetting one that is too thin, the former course should be adopted. Small work is often clipped in the vice, while red hot shape either by direct bending or by hammering, but it must not be left too long in the vice or it will draw the temper of the jaws.

Welding. The iron must be white hot, at any lower heat it is not in the pasty condition necessary for a good joint, but if left in the fire after it reaches the right heat it gets *burned.* It is liable to be covered with scale or oxide, which prevents the parts getting in close contact. Unless the faces are clean, the joint will not be sound. One way to prevent scale is to dip the face of the metal in clean sand when about red hot, then return to the fire and get welding heat. A tap on the anvil will now displace all scale. The sand will also protect the outer part from the action of the fire, while the heat *soaks* into the middle of the mass, so as to bring the whole to an equal heat. In a welding heat the metal is almost fused.

The surfaces to be welded must be convex. If hollow they will form a kind of pocket holding scale. When the surfaces are clean and at right heat, lay together and give a few smart blows to commence, then if large enough to retain the heat complete the weld, if not, return to fire to re-heat and complete. In thin or awkwardly shaped work, a rivet is sometimes used to held the parts together until welded. In all cases allow the central parts to touch first, then extend gradually to the edges driving the scale away as the joint closes. Avoid welds in bars that are subject to heavy pulling strain.

Welding Shafting. Anything under 3 in. can be done with the sledge. The ends must be upset, then level off and round, and weld in the ordinary way. Light weight shafting can be welded as a *butt joint*, as shown in Fig. 12, page 7, the ends being rounded as shown.

Steel requires special treatment varying with its composition. Do not upset steel, but before working it to a tool, round up the end under the hammer or it will probably split in working. Do not heat beyond a bright red or keep long in the fire, steel heated long in contact with air loses part of its carbon. Welding steel is often difficult, and depends upon the percentage of carbon it contains—some sorts will not weld, others are difficult. It is much easier to weld steel to iron than to steel. As a flux for welding, use either Silver Sand or Sand and Salt. Borax is a great favorite with some workers. Work the steel at a bright red, and do not hammer after it has lost color. In making tools allow plenty for grinding off, as however carefully made the steel will have lost part of its carbon near the surface, but is usually all right below the skin.

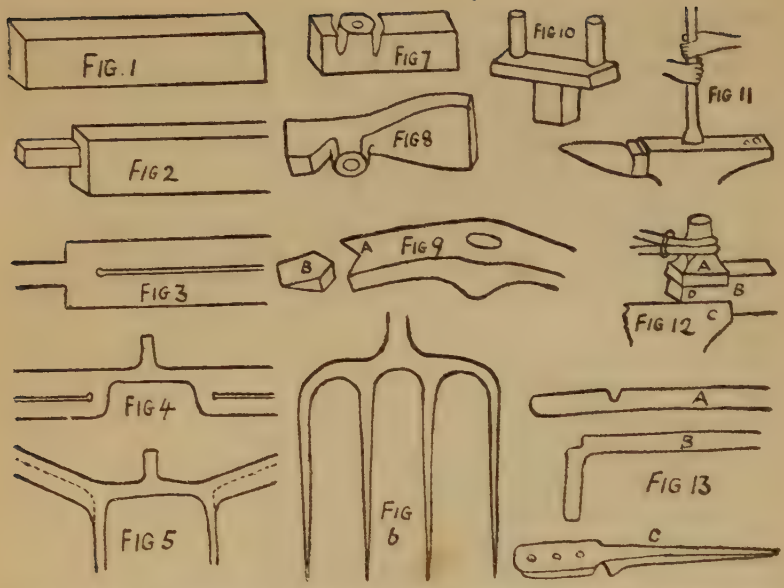
Tempering is a process by which steel that has been hardened is partly softened so that it will be less liable to break in use. Iron cannot be tempered. Steel that is unsuitable for a tool cannot be made suitable by any tempering process, and what is suitable for one class of tools would not do for another. To temper, the steel is made red hot, avoiding white heat which would burn out some of the carbon, and quenched in water. It is then *dead hard* and quite brittle. It is heated again to a lower temperature than before, which can be judged by the color the heat causes on a portion of the surface made bright for the purpose. When the correct color it is again quenched. Another way, when only the end of the tool is to be tempered, is to heat the end half to a bright red, dip the point only in in water, withdraw as soon as it has lost color, then allow the heat of the other part to re-heat the tip to the right color, and again quench. By this means the upper part of the tool is left soft.

To make a Ring. If large, the ring is shaped on the horn of the anvil, for smaller work use a piece of bar iron as a mandrel. Let the ends cross over and weld where they cross. Cut off all superfluous metal and reduce to thickness of the other part of ring, then trim up on the horn or mandrel.

Collar or Flange on bar. Make a ring as above larger than the bar, upset bar to size of ring, then weld on. Trim up with pair of swages.

Making a Bolt and Nut. Place a bolster (having hole that is just an easy fit for the bar iron to be used) on the anvil just over the hole. Heat a length of bar to white, upset the end until it is large enough to form the head, place in the bolster and hammer the projecting head till it forms a flat surface under the head, then remove and shape the head on the anvil. To make the nut blank, select some bar of suitable section and mark with chalk where it has to be cut, also where the holes are to be. Heat to full red, and cut half way through with the hot set. Re-heat and with flat-ended punch make the holes, using a bolster under the work. If greater strength is required use a pointed punch, go half-way through, then reverse and complete the hole. Open it with a drift, and cut or break off the separate nuts, which can be worked hot to shape required.

Quenching and Cooling. Whenever possible allow worked metal to cool slowly instead of quenching in water, especially collars and welded joints.



Figs. 1 to 6—Making a steel fork without welding, an example of the highest class of blacksmith's work.

Fig. 1—The bar of steel. Fig. 2—The same drawn down at end to form handle. Fig. 2—Split with set, avoiding a sharp edge to the split. Fig. 4—Bent outwards and ends again split. Fig. 5—Opened out. The dotted line shows where the metal is to be drawn out to form the outer pair of prongs. Fig. 6—Completed fork. If the right size of stock is used there is no waste in making this tool.

Figs. 7 & 8—Making an Adze from the solid. The hole is drifted through first, no metal being removed, then with curved cutter make two cuts as shown in Fig. 7. The remainder is hammer work.

Fig. 9—Steel tip welded to end of pickaxe.

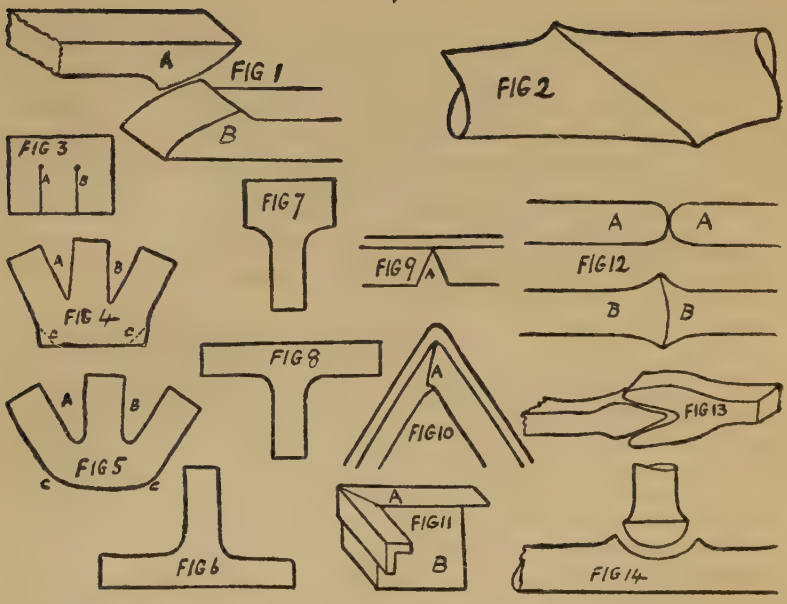
Fig. 10—Bending Tool for fitting in anvil, hot iron to be bent is placed between the pins.

Fig. 11—Upsetting end of bar on anvil.

Fig. 12—Using a flatter.

Fig. 13—Making a holdfast. The bar is nicked in as at A with a fuller, carefully avoiding a sharp edge to the cut, bent over as at B, so as to get the end over the side of the anvil where it is worked, C shows the finished holdfast.

If the anvil is not well bedded down on the wood block the noise will be much increased. If a large ball of lead (provided with a hole for the purpose) is stuck on the end of the anvil horn when the point is not in use, it will greatly reduce the noise.



WELDING.

Fig. 1—Shows ideal form of ends of bars prepared for welding, but is never done so neatly as this.

Fig. 2—Welding thick shafting.

Fig. 12—A, ends of thin shafting prepared for welding. B, after welding.

Fig. 13—Strongest form of weld, seldom used because of extra labour.

Fig. 14—Welding round iron for offset or T.

Figs. 9, 10, and 11—Welding angle iron for corner. A V piece is cut out of the web, then the iron bent *further* than the intended angle so that the ends will overlap. In welding this will spread and form a right angle. If at once cut to the angle it would open too far.

Making a T without a Welding.

Fig. 3—Iron of correct thickness is cut at two places with sets A—B, but avoid leaving a sharp edge to end of cut.

Fig. 4—The cuts are opened out.

Fig. 5—Opened further, ends of cuts rounded with fullers, and corners cut off and rounded.

Fig. 6—Shows completed T

Figs. 7 and 8—Another way of making a T by drawing down instead of cutting. Fig. 7 shows the metal partly drawn down to form the offset. Fig. 8—The sides of the head drawn out to complete the job.

Grain of Iron. Careful attention must be given to the grain of the iron (steel has no grain). This is easiest learned by regarding the bar of iron as a bundle of wires, or a piece of wood having the

grain lengthwise. An eye made near the end of a rod would be very weak, but a similar one at a distance from the end would be strong enough. When needed at the end it must be made by turning over the end and welding, really a hook with the end welded to the stem. Note the fork on page 6. Supposing this to be made from bar iron instead of steel, the grain of the bar is kept in the right direction throughout the working, and in the finished fork it runs in the direction of the length of the prongs.

Annealing is a process of softening both steel and iron by heating to redness, and delaying the cooling as long as possible. The longer the metal takes to cool, the softer it will be.

Case Hardening is a process of converting the outer layer of iron to steel. It is useful for many purposes, as the body of the article remains soft and tough, but the steeling seldom goes deeper than $\frac{1}{8}$ in. It is best done by packing the iron in a closed sheet iron box with plenty of animal charcoal (prepared by burning old leather). The box and contents are raised to a red heat and kept so, the longer it soaks the deeper the effect will be. On withdrawing from the fire, the box is opened and the whole contents quickly dropped into water, so as to prevent air getting to the work.

Brazing is a method of joining articles of steel, iron, or copper by a solder of brass. To braze say a key, the parts are well fitted together and tied, if necessary, to a piece of iron with iron binding wire. Some soft brass wire is lapped round where the joint is to be, and some borax powder mixed with water to a thick paste is plastered over all, the whole is now placed in the fire. If the heat is correct the borax will froth up, then melt to a glass, the brass will then melt and if properly placed run into the joint. The work must be at once removed and allowed to cool. Grain Spelter should be used if the article is of such shape that it will not run off. It is mixed with the borax paste.

Rivetting is often done where a welded joint cannot be made. The rivet must be of soft iron and must fit the holes well. The projecting part to form the head is equal to the diameter of the rivet. The plates must be in close contact or the rivet will swell between them, it is then hammered down or *upset* to form the head. Hot rivets hold closer than cold ones, and all over $\frac{1}{4}$-in. should be used hot or they would entail too much labour to upset.

Japanning. To get a nice bright black coating, equal in appearance to cycle enamel, dip the work while hot in some gas tar and allow to drain off, when cold it will be quite bright, but the bright surface is not lasting. The coating will, however, preserve the iron from rust.

Rust is iron that is no longer in a metallic state, but an oxide. It cannot be altered back to iron except by melting with some substance that will combine with the oxygen. When a coat of rust is removed, the iron has then lost part of its bulk. Ordinary iron rusts quicker than steel, and steel quicker than cast iron, this is due to the carbon present in the latter two.

COPYRIGHT

Brass Founding.

How to Mould in Sand, Plaster, &c. Melting & Casting Brass, Aluminium, Silver, &c. How to Build a Small Furnace.

By M. COLE.

* * * *

Brass is cast in moulds of sand, held in boxes called flasks. The lower half of the box is filled with sand, and the pattern pressed into it until only half projects, more or less, according to the shape of the pattern. The surface is smoothed from the edge of the pattern, or parting line, to the edge of the flask, and the upper part put on. Parting sand is sprinkled over that part of the sand not occupied by the pattern, and the upper part filled with sand and rammed down hard. A board having been laid on the top, the upper half is lifted off and the patterns removed. A hole or gate for pouring the metal, and some vents for the escape of gas or steam are made in the top of flask, and channels to lead the metal to the various parts of the mould are cut in the surface of the sand in the lower half of the flask. The moulds are then put in a stove or other hot place to dry and warm. When the parts of the mould are again placed together, the melted metal is poured through the gate, and when sufficiently set, a smart tap on the gate piece breaks it off, leaving the castings more freedom to contract. In *oddside* moulding to save time a plaster cast is used having hollows in it such as would be made by the patterns when pressed into the sand to exactly the right depth. The patterns are placed in these hollows, and the moulding proceeded with. *Plate Moulding* is a still further saving of time, as by this method the patterns instead of being loose and having to be bedded down each time, are replaced by a plaster or other plate having on each side projections taking the form of a half pattern and provided with channels and gate pieces, they are used in machine moulding where the work is done automatically. In *fine work* the face of the mould is covered with lamp black or charcoal powder, or torch burning pitch or other means being used to deposit a thin layer of soot on the surface which is pressed smooth by inserting the patterns and closing the flask.

The Sand is a special sort selected for its property of clinging well together when slightly damp, so as to retain the shape of the pattern after its removal, it is also porous allowing much of the gas to escape. After being used, the heat of the metal having burned the sand in contact with it, the layer nearest the casting can only be used for filling, not again put in contact with the pattern, but only a thin layer of new sand need be used.

Parting Sand is a fine dry sand required to dust over the surface of the sand between the pattern and the edge of the flask, to prevent the two lots of sand in the parts of the flask from adhering, and so breaking the surface when the upper one is lifted off. Bricks broken up to a fine powder, or any fine *dry* sand or charcoal powder.

Facing Sand must be new and sprinkled over the face of the pattern through a sieve of say 20 wires to the inch, or fine powdered charcoal, or pea-flour for the first layer, follow with new sand using a dredger or bag of open canvas to dust it on with, the sand forming a layer one inch thick.

Flasks are boxes of iron or wood in which the lid is as deep as the body, and the top and bottom loose boards, or really two frames of wood or metal of equal size, and provided with some means of bringing their edges exactly even all round. Usually this is done by projecting lugs, those on one frame having taper pins that enter into holes in the lugs of the other frame. An easier way is to screw strips of wood on all four sides of one frame so that they project over the frame, or by bolts or dowels. In any case the frames must be provided with means to ensure accurate refitting to the same position they occupied to each other when the sand was being rammed down on the pattern. For small brass work, a good size is 12 in. by 12 in., 4 in. deep each frame. These can be made of dry wood 1¼ in. thick, and well cramped at the corners. It is worth while to give these a couple of coats of good paint to prevent the damp from the sand soakihg into the wood and warping it. A few ribs of thin wood should be tacked on the sides lengthwise to hold the sand more firmly when lifting off, or a coat of clay water will serve the same purpose. The pattern is usually of wood, but when a lot of castings are required a metal one should be made. Patterns are expensive, and moulders do not have to pay for them, so that with a fragile pattern it is advisable to have only one casting made, and trim this up for use as a pattern. The requirements of a good pattern are (from a moulder's point of view) 1 –that it has enough taper to allow its being lifted out of the sand without disturbing the impression; 2– That it is quite smooth; 3 –so proportioned that the metal flows well to all parts, and in cooling it shrinks evenly. There are some shapes that cannot be cast to come whole after cooling, on account of some portions remaining fluid after other parts are set. If the pattern to be cast from is rough, it should have a coat of shellac varnish.—*See Section "Pattern Making."*

Moulding. Place a half flask (face downwards) on a board a little larger than itself, for lifting by after filling. Fill with old sand and press well down, level off the top, then reverse, and put the pattern in its place on the sand, pressing down till it has entered the sand far enough, viz:– –so that both parts of the pattern will leave the sand in their respective halves of the flask without breaking the edge of the mould. This is very important, and a good deal of skill is required to do it properly. For example, in moulding a ball: if mor than half is under the sand, it will break the edge in pulling out, while if less than half is in the one side of the flask, more than half must be in the other side and do the same damage there. For

this reason a ball is a difficult thing to mould, and the pattern is either made in halves or has a line on it as a guide. Steam engine cylinder patterns are usually in halves, and other patterns where exactness is important. All properly made patterns are tapered both sides, except those that have one face only and are flat at the back, these are moulded in one side of the flask, the back level with parting line, and are very easy to work with, being laid on their backs on the level surface of the bottom flask.

Under Cut Patterns are made in two or more pieces fastened together with wires so that after sinking them in the flask, by removing the wires the pattern can be withdraw in pieces.

Parting Line. The pattern having been bedded down as required in the first half of the flask, the sand must now be smoothed down with a *smoother* or small trowel from the edge of the flask to the *parting line* of the pattern, or such line as will enable both parts of the mould to leave the pattern. This is usually a straight line, but not invariably. In patterns of an irregular shape it must be trimmed to flowing curves from the parting line of the pattern to the edge of flask, gradually diminishing till it forms a straight line or flat surface. A little parting sand is now sprinkled through a sieve on to the sand and the other half of flask put in position, the uncovered half of the pattern projecting into it. Some new sand is sprinkled through the sieve to form a layer say one inch thick on the pattern and plenty of of old sand added and well rammed down with a piece of wood, adding more as required, but carefully avoiding those places where the pattern comes near the surface, ramming most where there is no pattern until level with the top of the flask. A board is now put on the top of the flask and the whole affair turned upside down, so that the bottom of the flask is now at the top. This half is carefully lifted off with the sand it contains, if necessary, loosening it round the edge of the flask, the sand will fall out of it and what remains on the pattern is brushed off with a soft brush (small hand brush). A little more parting sand having been sprinkled over the sand, between the pattern and edge of flask, replace the half flask and proceed to fill as before, ram the sand and level off. A board is now put on top of the half flask ahd it is lifted off and reversed.

Gate for Pouring. This must be arranged for before filling the second part of the flask. Place a piece of brass tube $1\frac{1}{4}$ in. wide or a taper plug of wood so that the bottom rests on the sand at the parting line, in an unoccupied corner of the flask, and when the sand has been rammed down, remove the plug leaving a hole through which the metal is to be poured. It leaves a sharp edge on the sand which must be rounded with the finger, or some of the sand will be carried down with the metal, The top of the flask is now lifted off and laid on its side, as there is then less risk of the sand falling out by its own weight.

Removing the Patterns. These must be lifted out very carefully. If there is plenty of taper, and they are quite smooth, this is easy enough, but usually they require a little rapping to loosen them. If so, it is well to wet the sand a little just round the edge where it

touches the pattern, using a rag dipped in water, and allowing it to flow down one corner of the rag while drawing it along the joint. Rapping always causes the mould to enlarge and consequently the casting to be a little larger than the pattern. In metal patterns a hole is drilled and plugged with soft wood so that a pointed tool can be inserted for lifting with. Heavy patterns are lifted by screw-rings (as used for picture rings) screwed into them.

Runners and Vents must now be made. Runners are channels cut in the sand, leading the metal from the gate to various parts of the mould, and it is important that they are large enough, especially when the castings are small. Where possible, the metal should be led, not only into the mould but out of it at the other side, so as to get a flow through the details of the mould, thoroughly heating it before the metal that is to form the casting reaches it. It is good practice to put a hole similar to the gate at the other corner of the flask to form an *air gate,* the metal driving the air before it and rising till it fills, this will ensure equal pressure of metal in all parts of the mould. *Vents*, to allow the escape of steam and gas (produced by the heat of the metal and the moisture of the sand) are made by piercing the sand in the upper flask at the highest parts of each detail of the mould with a wire. A fine knitting needle does well for this as it is smooth and pierces better than a rough wire would do. Where the gate joins the main body of the casting the opening should be small so as to allow the lump of metal in the gate to be easily broken off.

Fettling the Mould. There is usually a little disturbance of the sand in removing the pattern, this must be dressed over with tools called *Smoothers* of various shapes, as small trowels, balls, corners, &c. Very good ones can be made from bits of brass sheet and tube.

Dry the Mould by any suitable means, either in an oven or near the fire. This is with the double object of expelling moisture that would produce steam, and to prevent chilling the metal. When done and quite warm, place the two parts of the flask together very carefully to get exact register, as the accuracy of the casting depends on this, and place on the floor with a heavy weight on it to minimise the risk of accidental disturbance.

Smoking the Mould is often done for good work where the natural surface of the casting is preserved, but for such as are to be turned or otherwise worked up to a smooth face, this may be omitted. The mould, before the flask is closed, is smoked by burning pitch, resin, or any other material that gives off a dense black smoke, to form a layer of soot on the surface. The patterns are replaced and the flask closed so that the pressure of the pattern gives the smoked surface a smooth skin. If the pattern has been blackleaded and well polished it will further improve the face. A rag dipped in paraffin oil makes a good smoke torch, or lamp-black may be dusted on the mould through a fine sieve. Black-lead mixed with stale beer gives a good surface.

Pour the Metal from the crucible into the gate until the mould

is full and the metal rises in the air gate to the top of the flask. If too little metal is used it will not have pressure enough to penetrate the details of the mould. For this reason some flasks are made to pour at the side, so getting a better pressure. When the metal in the gate is set, it must be broken off by pressing with an iron rod to allow the casting greater freedom to contract.

Half Patterns. For special work the pattern is sometimes made in two or more pieces fastened together with wires, so that they can be removed from the sand in parts after the wires are withdrawn. This enables patterns to be moulded that are so shaped that they could not be otherwise withdrawn.

Hollow Castings, Cores, and Core Boxes. When a hollow casting is required, it is necessary to place a core in the mould of such shape that the metal flows round it instead of filling the mould, so that the contents of the mould are partly a metal and partly a heat resisting substance that occupies the hollow in the metal, this is broken up and removed when the casting is cold. To hold the core in position in the mould, some special pieces are put on the pattern called *prints*, in moulding the patterns these prints leave hollows, usually two, one at each end of the pattern, and the core, resting in these, the metal flows round it instead of filling the entire mould. For plain holes, round or square, the cores can be made by hand from a mixture of sand and clay water, with a little flour or pea meal to bind it together. This is mixed up to a stiff paste and rolled or otherwise worked to shape, when dry it can be smoothed with a file if required. For more accurate holes, use brass tubes to fill and press out the core. For cores of irregular shape, where accuracy is required, core boxes are used.

Core Box. This is usually a wood mould of two or more parts in which the composition forming the core is rammed. When opened the core is removed and dried, it requires very careful handling while moist. If very thin, it may be strengthened by using some wire or thin nails to form part of the core. Some holes should be made with fine wire to help the moisture to escape while drying. The core is of course longer than the cavity it has to form, the extra length resting in the hollows of the mould formed by the prints. To save the expense of wood core boxes, they are sometimes made of Plaster of Paris, which, with care, does well for the purpose, but is more likely to be broken (*see plaster moulds*). For a single casting it is seldom worth while to make a core box, as the core can always be carved or moulded.

Chaplets. When a core is supported in a mould by one end only, as is sometimes the case, part of it rests on some bits of metal placed in the mould. In iron founding, these are usually nails pushed in, in brass work either brass wire or bits of sheet brass. These are not desirable, but there seems no other way of getting the same result.

Selecting the Metal. There are many qualities of brass varying from the finest bronze of 90 per cent copper, 10 per cent of tin with sometimes a little zinc to increase hardness as in bronze coinage, down to the stuff used by builders for house fittings, locks, &c.,

mainly of zinc, often even lead added, and copper enough to colour the mass a little, it being further darkened by lacquering, still it is brass. In a small foundry old stuff is largely used, and the previous use of the article is a good guide as to quality. Steam fittings and water taps are always high standard, also any pieces that have a good deal of turning or screwing about them. Small gas fittings are very low, and locks usually worst of all. In small stuff as filings and turnings of brass, a few bits of iron usually get mixed in; to remove these a magnet must be used. It need not be a very powerful one, but should never be put away without a bit of iron across the end. *Caution.*—In melting scrap be careful there is no moisture in any of the pieces, or the furnace may be blown up. A little water makes a lot of steam.

The metal should be broken up small enough to fall to the bottom of the pot. If too large some of it will jam across and be suspended long after the bottom lot is melted, and the bottom lot burned before the top lot melts. Scrap having large surface such as wire should be hammered solid before putting into the pot. Tin should be added after the copper is melted.

Crucibles, in which the metal is melted, are made of either a mixture of clay and plumbago or of a special quality of fire clay, and with careful handling can be used several times. They are made in many sizes so that there is a saving in using the smallest size that will hold the required quantity of metal, and it is quicker heated than a larger one. The crucible is lifted with special tongs, and held by them while pouring the metal. A new crucible should be placed mouth down in the furnace and made red hot, then be slowly cooled before it is used for metal.

Melting the Metal. Make a good fire in the furnace and allow to burn clear and free from smoke, add of good layer of coke, and when this is well started put the crucible, charged with metal, on the fire covered with a piece of an old crucible or slab of fireclay to prevent coke getting into it, bank round with coke and close the furnace. The metal should be ready for pouring in half-an-hour. On removing stir well with a piece of wood, and remove dross from the surface as far as possible. Lift with the tongs and pour into the mould, an assistant with a metal rod should be handy to remove any dross there may be, and prevent it going into the mould with the metal.

Melting New Metal. Place the copper in the crucible first with a little lump borax for flux, when melted add the tin and zinc, and remove as soon as the lot is melted. If left too long the zinc and tin will be burned out. If the crucible is uncovered in the fire, the sulphur fumes from the coal and coke will spoil the metal. For small jobs, the melting can be done in a blacksmith's forge fire, or even in an ordinary kitchen fire-place, if a sheet-iron draw plate is used to cover the open part and get a good draft. Nasmith says in his autobiography that, when a school boy, he made brass castings in his bedroom, but that was in Edinburgh where chimneys are tall and have a good draft.

Making a Small Furnace. The following is an easy and cheap way of making a small furnace for melting brass, &c. Make a

cylinder by rolling up some wire netting say 1in. or 1¼in. mesh, about 13 feet of 24 in. wide will do, this will form a cylinder 15 in. wide of three layers. Tie with wire at several places so as to get it compact and well shaped. Provide three U shaped pieces of iron rod 1¼in. by ¼in., each to be 32 in. long before bending, and bent so that the sides are 4 ins. apart, to form the legs of the furnace, these must be tied with wire inside the wire cylinder, so that they project 6 ins. beyond the edge. See that they are level so that the furnace will be upright when completed. For the fire bars cut up a length of 1 in. square or round iron to make 6 lengths graduated so that when pushed through the netting they will project 1 in. outside the wire. They should be ¾ in. apart, and about 1 in. above the bottom of the netting and well wired on to it. The spaces each side between the bars and the wire must have some ¼ in. iron rod inserted, running across like the fire bars, but slanting upwards, so as to hold the clay to be moulded each side of the bars. All the bottom except the bars being closed airtight. Fire clay (which is sold in a dry powder) is worked up with water to stiff dough and rolled out to say 1¼ in. thick rolls of convenient length. These are now placed on the inside of the wire cylinder, commencing at the bottom and working upwards until it is all lined with the clay. Each layer must be well pressed down and worked so that it penetrates the wire and forms a layer not less than ½ in. thick outside, and a total thickness of 2 in., also covering the bottom except the space occupied by the fire bars, this part should slope upwards. The clay can be smoothed with a bit of wood kept wet, adding more clay when required to get an even surface. The top of the stove must now be made. This can be of sheet iron with a turned over edge of say 1½ in. and should fit fairly well, but can be luted on with clay. It is provided with a piece of pipe say 3 in. long and 4 in. diameter for a length of stove pipe to fit on to form the flue, also an opening near the outer edge say 8 in. square for feeding the fire and inserting the crucible. A lid must be provided to cover this hole. It is a great improvement and saving of fuel if some rod is worked across near the top in the same way that the fire bars were inserted, but leaving an opening to insert the crucible. Some clay is worked on to this and it reflects the heat downwards that would otherwise be wasted in making the iron top red-hot. To burn the clay make a good clear fire in the furnace and feed with coke, putting on the top and using a 6 ft. length of stove piping to get draft. Cast iron rain-water pipe answers well, though sheet iron stove pipe is lighter and less liable to be broken.

Potters Clay or pipe clay is sometimes used for moulds when very fine work is required. It is sold in lumps. It must be worked up with water to the required state. If made too thin it will thicken by the evaporation of the water if made into balls, and should then be well hammered with a mallet to consolidate it. It is the same sort used by artists for clay modelling. It can be used in flasks like sand, or in a plain frame just to hold it together. When the mould has been made and the surface is dry, it should be blackleaded till the surface shines. It requires more venting than sand.

Plaster of Paris is often used for small work, and if properly used is one of the best for the purpose. It is used by dentists for

casting the die and counter-die, between which a sheet of gold or dental alloy is struck in making a metal palate for artificial teeth. The plaster must be of a specially good quality, quite white and as fine as flour. It should be bought from a reliable firm and kept in air-tight boxes away from all trace of damp. It will then keep good for several months. Plaster would crumble with the heat required, unless some material is used to bind it together. Powdered French Chalk (say 25 per cent) is a good material for the purpose, but for a mould that has to be handled a good deal, a cheap quality Asbestos Fibre is more suitable. It must be pulled apart till quite fluffy, mixed with the plaster after the water is added. Powdered coke is also used, but does not give as fine a surface as the other two. To mix the plaster for small jobs, use a basin, usually a pint will be large enough, half fiill it with water, then sprinkle the plaster into it through a small sieve, rejecting all lumps, or sprinkle with the hand but so that each fragment is wetted as it sinks in the water, continue until the plaster reaches the surface of the water, then stir with a flat stick and use at once. Any unused plaster left in the basin should be wiped out before it is quite set, and thrown away as it cannot be used again.

Making a Plaster Mould. The pattern must be bedded down sand, as in sand moulding, using a box of suitable size and leaving half the pattern projecting. Smooth the sand down from the parting line of the pattern to the edge of the box, and see that it is wet on the surface, otherwise it will absorb the moisture of the mixed plaster, and make it crumble. To economise the plaster, a hedge must be made round the pattern about two inches from it. The easiest way to do this is by inserting bits of sheet zinc, so as to form a continuous line round the pattern and projecting say 1½ inches above the sand. The surface of the pattern must now be well oiled or greased, sweet oil is best for delicate work, for larger use margarine melted and applied with a brush. Pour a little of the mixed plaster on the pattern, and in order to spread it evenly all over the pattern and avoid air bubbles, blow through a tube on the plaster till a thin skin comes over the pattern, then pour on all that remains in the basin, spreading it as evenly as possible. A second lot is now mixed and applied if necessary, so as to get at least 1½ in. thickness, which is enough for most moulds. The top of the mould must be trimmed flat so that it will stand steady when reversed. If this cannot be done, a small bag of sand must be provided for the purpose. If left more than a couple of hours between the first and second layers, the plaster must be well wetted before the second lot is put on. When quite set, which it should be in a half-hour, the second half of the mould must be made. Dig away sand from round the pattern, so that the hand can be got under it, and lift it up with the plaster, then turn over so that the pattern rests in the plaster (half being out of it). Trim up the parting line and scrape the level surface free from sand. Next make three or four holes in the flat surface of the plaster, these are to form keys to make sure that the halves of the moulds come to exactly the same position again, they are easiest made with a coin, twisting it round until half the depth is cut out. The plaster of the second half of the mould fills these. Put a belt of clay round the

half mould to hold the plaster when poured in, just as the bits of zinc did in the first half. Oil the pattern and the flat plaster, and make the second half just as the first was done. When set, separate the halves, remove patterns, do what trimming up is required with a knife, and cut channels, gates and vents, and set to dry. If left to dry it would take take three weeks, so must be placed in an oven till all the moisture is baked out of it. The surfaces of the mould should be blackleaded and then polished when cold. Before pouring metal, the mould must be made hot—not merely warm, the parts being tied, or cramped together tightly.

Plaster Core Box may be made the same way, using a clay model of the core. In this case as the plaster is used cold it need not have more than a moderate drying, but the surface must have several coats of shellac varnish till quite smooth and shiny. The varnish is made by dissolving shellac or good quality sealing wax in Methylated Spirits.

Gold and Silver can be cast in sand or plaster moulds, but for small articles Cuttle fish bone is used. This will stand any ordinary heat. Two pieces are used, scraped or rubbed to a smooth surface, the flats are brought face to face and the sides are now cut away and nicks cut in them, this is done to ensure the two parts being brought to the exact position again. Half the mould is cut out of each side or it is made by pressing a metal pattern into the bone which is very soft. Gate and channels are cut, and the gold or silver poured in. In melting gold or silver, a block of either charcoal or asbestos is used with a hollow scraped in it. Another piece is used to cover it and keep in the heat, a portion being cut away for the flame of the blow-pipe to enter, or the metal can be melted in a small crucible if the quantity is sufficient. Borax is used as a flux. A candle broken up in a small tin box and the wick cut in four pieces and placed in one corner will give a flame large enough to melt a half-sovereign with a mouth blow-pipe. A gas blow-pipe, is of course, much easier and cleaner and avoids unpleasant smell.

Wood Moulds can be used for casting lead, and can be used several times, as the heat chars the wood, and so preserves it, but the wood should be dry and free from resin.

Type Metal is a very suitable material for small models or ornamental articles. It is hard enough for a working model, yet can be melted in a ladle. A bit of tallow should be put on the surface of the metal to keep it clean when melted. If cast in a smooth brass or copper mould, it comes up quite bright and smooth. The metal can be bought from any printer, as they sell old type for melting up. The small type is the hardest. Type metal, on account of the antimony it contains, expands in the mould just before it solidifies, hence the sharp cast it gives, but if any bits of zinc are among the type they will spoil the mixture.

Waste Moulding or Lost Wax Process is used for objects of art, where the pattern is not required again. The wax pattern is bedded in either sand or plaster so as to completely cover it, provision being made at such parts as are not seen for gates and vents. On heating the mould, the wax is melted and poured out, and the metal poured in to replace it. Another method allied to this is to cast a wax

model in a two-part mould in the ordinary way, this is then tooled up, and any required undercutting done, making a model that could not be moulded in the ordinary way, but suitable for the wax process.

Paper Moulds are used for casting type metal of a softer quality for stereotypers, and are used for small article. The sharpness may be judged from the fact that they are used for printing from. The paper is put on in alternate layers of tissue and blotting, the latter soaked in flour paste. Every foreman has some secret mixture for this purpose, but good work can be done with ordinary flour and water, mixed to a thick batter and boiled until it changes color. It should be thick and spread with a brush on both sides of the blotting paper, and left to soak in several hours, when put on the type (previously oiled) covered with a wet cloth, and beaten down with a stiff brush so as to force the paper into the details of the type. A cover is put on and pressure applied to prevent the paper warping with the heat, the whole is heated until all moisture is forced out of it, when it is ready for the casting, but should be sprinkled with finest french chalk before using.

Metal Moulds give the finest castings, but for brass work would have to be of iron, for softer metals brass or copper moulds are used and the fineness of the work so cast can be seen by examining the Japanese fancy goods so largely sold. They are of pewter, but contain a little antimony. The colored portions are done with lacquer, tinted with dyes applied with small brushes. The finest metal moulds are made by electo deposition on a pattern, preferably of metal, but it may be of gutta percha coated with black lead. The process is a very simple one, and the battery cheap, as only 1 volt current is required it can be done with a single cell. A deposit as thick as tissue paper is formed in about ten hours, but sometimes as long as three weeks is required for sufficient thickness, as in reproducing a matrix for type founding. Other metal moulds are made from brass or other castings tooled up by hand, as in the moulds used for casting toy soldiers, &c., but one of these having been made, any number can be copied from it by electro-deposition.

Cliche is a process not much used. A pot of metal is melted and poured into a suitable box, open at the top, the surface is carefully cleaned, and when partly set but still soft, the pattern is pressed on it, just as a seal on soft sealing wax. The impression so obtained is used the same way to obtain a copy of the pattern.

Stone Moulds were in use for casting articles of bronze before sand or clay moulds were invented. Some are now in existence made before iron was used for tools or weapons. They are of slate, and are intended for knives and spear heads. Moulds can also be carved from pumice stone or bath brick, both of which stand heat well and can be used several times.

Pewter is one of the most effective alloys for casting useful or ornamental articles. It varies greatly in composition from a very hard mixture, formerly used for dinner plates, to the softer but brighter sorts for teapots and drinking pots. If cast in a polished brass mould, the pewter requires very little finishing.

Rubber, Vulcanite, and Ebonite cannot be melted and cast. The articles are made in moulds which are filled with a form of

rubber called Mixed Sheet, a mixture of pure rubber and sulphur in varying proportions, which is then heated and forms valcanised rubber. Where little sulphur and low heat are used the result is an elastic rubber, greater heat and more sulphur gives Ebonite, an intermediate form giving the vulcanite used to mount artificial teeth.

Contraction of Metal in cooling must be allowed for in large castings at the rate of $\frac{1}{8}$ inch per foot length, but in small articles up to 5 inch it may be disregarded, as the casting is usually larger than the pattern.

Avoid the Fumes of Melted Metal, they are very injurious. *It is contrary to law to buy or sell less than 56-lbs. of old brass or zinc*, but old articles may be bought or sold if in any way useable, as second-hand stuff.

Glass is never fluid enough to be poured like metal, but when heated to a pasty state it is moulded by squeezing in brass moulds.

Aluminium can be melted and cast the same as brass, though a little extra care must be used to ensure a good casting. It is a very profitable branch of founding, as the metal. on account of its lightness, costs no more than the commonest brass for a casting of equal size, yet a very much higher price can be obtained. It is about one third the weight of brass, and it melts at 626°C equal to 1160°F. It may be melted in ordinary plumbago crucibles or iron pots, but they should be lined with a paste of lamp black and treacle, which should be allowed to dry in a warm place for several days, then be baked. If this cannot be done use an iron crucible. The iron may take up a little aluminium, but the aluminium will not take up any iron. (A little aluminium added to iron in melting causes it to flow better). No flux is used, but each piece of aluminium is dipped in Benzole before putting in the pot. About one third of the required quantity is first put in the pot, when that is melted the remainder is added a little at the time as it melts. The heat should not exceed a dark red color, and $\frac{3}{4}$-hour allowed for melting. If too hot it gives the casting a bad color. Before pouring, stir well and skim off any dross. Let the mould be warm and extra well vented. If of green sand, the gates and runners must be larger than for brass. Pour the metal slowly. If possible when moulding give extra height to the head, so as to get pressure of metal in the mould. See the crucible is red hot before putting any metal in it, and provide a well fitting cover that can be easily lifted off Allow the casting to cool slowly, and when set, loosen the sand round it to allow free contraction.

THERMIT. Melting Metal without fuel. A mixture of powdered Aluminium and one of the Oxides of Iron is placed in a suitable receptacle, and a small quantity of Aluminium in fine powder, mixed with a form of Barium (or other re-agent) is placed on the top to act as a primer and provide the heat necessary to start the chemical re-action. The primer is usually ignited by a plumber's torch, and the whole mass rapidly becomes white hot, and the now melted iron can be poured into moulds. It is much used for jointing the ends of tramway rails. It is also used for repairing large castings when broken.

Brass for various purposes:—

	COPPER	TIN	ZINC
Commonest Brass	1	1	—
Medium ,,	2	1	—
Good ,,	3	1	—
Pinchbeck for Ornaments	4	1	—
Brass for Machine Work	20	3	3
,, ,, Heavy Bearings	32	1	5
Hard White Brass	1	16	16
Soft ,, ,,	10	10	10

Babbit Metal, for bearings :—Copper 8. Tin 84. Antimony 8.

Dentists' Alloy, very hard sharp casting :—
Tin 16. Zinc 1. Antimony 1.

do. to melt at very low heat :—
Tin 8. Lead 1. Bismuth 1.

German Silver or Nickel Silver:—Copper 50. Lead 25. Nickel 25.

Pewter, varies greatly in composition, a few are here given :

a—Tin 85. Antimony 10½. Copper 1. Bismuth 2½ Lead 0.
b— ,, 84. ,, 0. ,, 0. ,, 0. ,, 16.
c— ,, 100. ,, 8. ,, 2. ,, 2. ,, 0.

NOTE.—Metal moulds for Pewter must be painted over with white of egg to prevent adhesion.

Bronze as used in ancient times for weapons and tools.
Copper 85 to 90. Tin 10 to 15.
The casting hammered to increase the hardness.

Lithium is the lightest known metal, it is about half the weight of water, but is not commercially available. Next comes **Magnesium,** much lighter than Aluminium, but unsuitable for working alone. A mixture of Aluminium and Magnesium forms an alloy that works better than either of the two metals, and is considerably lighter than Aluminium.

Alloys melt at a lower heat than the metals of which they are composed, for example :—Tin melts at 442°F.; Bismuth 497°F.; Lead 612°F.; while a mixture of Tin 5, Lead 3, Bismuth 3, melts at 202°F., or lower than boiling water. Cadmium still further reduces the melting point.

Silver in a pure state is too soft for any purpose except filagree work. It must therefore be alloyed with copper, or with a mixture of zinc and copper, the toughest alloy being two parts of silver and one of copper, and this melts at a lower heat than silver, so can be used as a solder. Tin reduces the melting point, but makes the mixture brittle. Lead has the same effect in a much greater degree. Standard silver for coins and hall-marked silver goods is 222 silver alloyed with 18 of pure copper. Antimony renders silver brittle, but gives a sharper cast than other silver alloys.

Malleability of Alloys is independent of the malleability of the metals composing the alloy. Gold and lead are two of the most malleable of metals, yet if one part of lead be added to 1000 of gold, the resulting alloy will be quite brittle.

COPYRIGHT

Pattern Making.

By M. COLE.

* * * *

Metal Castings are made by pouring the melted metal into a hollow of the required shape made in sand held for the purpose in a two-part box or *Flask*. To form this hollow a pattern is required, usually of wood. The method of moulding is described in section "**Brass Founding,**" which should be read before attempting to make a pattern. The best pattern is the one that gives a casting requiring the least time to be spent upon it working it up. The smoother the cast, the less file work it requires. If the pattern is rough, it draws away particles of sand, and causes a rough surface on the casting. If not tapered enough to allow of its being drawn easily from the sand, it must be rapped or moved about a little to release it, thus making a larger cavity than the pattern itself, and consequently giving a larger casting. If any of the corners or interior angles are sharp, some of the sand will remain in them, and the mould will require a lot of dressing by hand, which is avoided by using a properly made pattern. The most important point in making a pattern is that it can be removed from the sand without breaking off even the smallest detail of the mould. Another fault of sharp angles is that in cooling, that part sets under tension, and the result of this irregular cooling often causes fractures without apparent cause. Another thing to be carefully avoided is having a thick lump touching a thin flat piece; the thick part, taking longer to cool, drags the thin part out of shape. There are some shapes that it is impossible to obtain a sound casting of, although there is no difficulty in moulding or pouring, and only because of one part setting while others near them are still fluid. In order to be able to cast shapes which could not otherwise be drawn from the sand, patterns are sometimes made in several pieces, skewered together with wire so that after it is bedded in the sand, the parts of the pattern can be withdrawn one at the time. Good patterns are expensive as they entail a great deal of labour, but it pays in the end. When a large number of castings are required from one pattern, it is worth while to pay say £1 extra on the pattern and core-box, if by so doing there is a saving of even threepence in the labour to be put on each casting. The first eighty pay for the extra outlay, and after that the profit begins. When only an odd casting is required, it becomes a question of which is the cheaper, to work the wood pattern or the casting.

Drawings. It is a mistake to make a pattern without first making a full-sized and accurate drawing, so that the wood can be marked off direct from the drawing. This not only ensures greater

accuracy, but is really a saving of time. If too large for paper, the drawing should be made on a planed board. Drawings of cross sections of each part should be made to show thicknesses. Do not work too close to the size of the finished article, or the casting may be useless through being $\frac{1}{8}$ in. too small, on the other hand every bit that has to be removed means so much labour and cost. Small drawings may with advantage be made on paper ruled in $\frac{1}{8}$ in. or $\frac{1}{4}$ in. squares.

Contraction or Shrinkage of Castings. A casting is smaller than the mould in which it was cast. but the mould is usually larger than the pattern owing to disturbance in lifting it out, so that in small patterns the contraction of the metal may be disregarded. In larger patterns, say over 6 in. allow $\frac{1}{10}$ in. per foot for Cast Iron, and $\frac{3}{16}$ in. per foot for Brass. Heavy castings contract less than light ones of the same size. Where very exact work is required, it is necessary to allow for shrinkage of the pattern, unless made from wood that is very dry and well seasoned, even then the coat of varnish must be kept in good condition.

Timber. For small and medium size work, mahogany is the best to use, and expense is the only reason for its not being used for large work also, as it is less liable to warp than soft wood. For large patterns use yellow pine or any well-seasoned white wood free from sap, knots, or resin, and of straight grain. However carefully the wood is planed, it is almost impossible to get a smooth surface on a knot, and as the knot shrinks, less than the surrounding parts, even if smooth at first it will show later, not remaining a dead level. As an instance of how small an irregularity will show in a casting, if anything is written on soft wood with a hard pencil, it will be readable in an iron casting taken from it, unless smoothed over by the moulder. Cigar boxes are good material for small work. Holes should be plugged with wood of the same sort glued in, never with softer wood or the plug works loose by greater shrinkage.

Tools, and the method of using them, do not differ much from those used in cabinet making. so there is no need to describe them here. They must be in first-class order, chisels and plane irons sharp. The tools must include several bradawls and gimlets, some of them much thinner than for ordinary cabinet work, a sweep or bow saw, round-faced planes, wood rasp and coarse file.

Glue is used very largely in putting patterns together. It must be of the best quality, soaked overnight in cold water. Pour away the water and melt the glue in a double glue pot, it will have absorbed just the right quantity of water. Make fresh glue in preference to frequently re-heating the old use it hot and rub well into the pores of the wood, where practicable rub the two glued surfaces together to expel any air, in all cases put under pressure either by screw cramps or weights until thoroughly set, allowing several hours for the purpose. Although a well-made glued joint is stronger than the wood it joins, it must never be depended upon alone for patterns, as moisture weakens it. Either screws or nails must also be used.

Screws. Some very thin screws are made purposely for pattern makers, they are no thicker than an ordinay nail of the same length. There are also some extra thin nails and sprigs, and for special work needle points are sometimes used ; but screws should be used where ever possible in preference to nails. The heads of the screws should be well below the surface of the wood, and the hole filled up level with putty or cement.

Dowels. Brass dowels and sockets made for pattern makers' use and are of various styles, some being mounted on plates for screwing to thin work. There is no special difficulty in fitting them. Very good dowels can be made from brass screws. The screw head is cut off and the top of the body rounded so that it enters easily into the other half of the pattern. The easiest way to fit these is to bore a hole with a very thin gimlet-bit through both parts, this marks the place where the screw in one half and the socket in the other half are to be fitted. The hole for the latter being enlarged with a small centre-bit.

Paint and Varnish. In order to get a smooth surface and to prevent moisture injuring the patterns, it is necessary to either paint or varnish them, though this is seldom done when the pattern is to be used only once. If oil paint is used the pattern must be given a coat of good hot size. This, when dry, should be smoothed with glass-paper, and a coat of good quality red lead paint given, if necessary go over this with glass-paper. Any cracks or holes must be stopped up before painting or varnishing. Putty is often used, but it is much better to glue in bits of wood or shavings. Nail holes should always be plugged, Shellac varnish is more frequently used for patterns than paint, as it dries so quickly. To make it, put some shellac in a wide-monthed bottle (provided with a good cork), pour on enough Wood Naptha or Methylated Spirits to more than cover it, and cork the bottle to prevent evaporation. The shellac takes some days to dissolve, and can be hastened by stirring up with a stick. It can be coloured by adding red ochre or lamp black, or by any colour Aniline dye. Prints are usually coloured red, parts that have to be machined or worked up yellow, ordinary parts left as cast black. There is no fixed rule in this, in some parts of the country prints are black and finished parts red. It is often necessary to give more than one coat of varnish before the grain is filled. If this is done glass-paper should be used between the coats, or Pumice stone can be used, but if so it must be kept to a level surface by occasionally rubbing on a flat stone. Shellac varnish is applied with a soft brush, copal or other oil varnishes with an ordinary paint brush,

Clearance or Taper. The amount of clearance should be as much as can be given without spoiling the design, but never less than $\frac{1}{8}$ in. to each 3 in. A smooth surface with small clearance will work better than a rough surface with greater clearance.

Parting Line. When the shape of the pattern is such that it is difficult for the moulder to judge where the parting line is, as in the case of a ball, it should be marked on the pattern, or better still, the pattern should be in halves.

Half-Patterns. Patterns for work that is intended to be very accurate should be made in halves. The reason being that in separating the halves of the moulding flask, half the pattern remains in each and so is separately withdrawn, avoiding the risk of damaging the other half of the mould, as it would be if the pattern is dragged out of it. The halves are fitted with dowels to ensure accuracy.

Leather Fillets. To avoid sharp angles, which are both bad to mould and a source of weakness in the casting, angles are filled up by a fillet or strip which alters the sharp angle to an easy curve. This is easily done in straight work, but on curved work it is often very difficult to make a neat job of it with wood. A strip of leather cut to suitable section should be glued into the angle. It should also have a few sprigs in it to hold it down in position while the glue is setting.

Turned Work. A good deal of pattern making is done in the lathe, and so far as it goes, does not differ from other wood turning except that it is usually very light and slender, and would be too weak for any useful purpose if in wood. Much of the turning is done on the face plate which is of wood. Very thin work can be glued to the plate with a thickness of brown paper between. This is easily separated by inserting the edge of a sharp chisel, a tap will split the paper leaving part of it on the work, which can be removed easily by wetting it. Wood turners are very apt to leave their work square instead of taper, unless the necessity is specially pointed out to them. Flanges forming part of turned work should not be turned from the solid as the grain would be the wrong way, but from a piece of board, and if necessary, in two parts to fit into a groove turned in the work for that purpose.

Prints and Cores. In order to obtain a hollow casting, a core must be made to exactly occupy the required space. The melted metal flows round the core, which is afterwards broken up and removed, leaving a hollow. The core is made longer at each end than the hollow, and these extra lengths rest in hollows made in the sand by *prints* or small pieces put on the pattern for that purpose. Wherever possible, the core should be thus supported at both ends, but in some cases this cannot be done, so the print must be extra long and strong enough to support the weight from one end assisted by *chaplets* if required. The ends of the core should be rather larger than the print as it easy to reduce it a little, but difficult to increase the size, and if loose, the core will not occupy the correct place in the mould.

Core Boxes. Plain cores can be rolled or shaped by hand or made in bits of tube, but a core of irregular shape requires a core-box to make it in. This is really a mould of wood instead of sand, provided with brass dowels to ensure the parts fitting together correctly and accurately. The hollow is carved out with the usual tools, and must be smooth like a pattern. It must have plenty of clearance, or taper, or the core will not readily leave it. It must be very strongly made as the sand has to be rammed hard into it. The core follows the general shape of the pattern, but of so much less measurement as will leave the required sized hollow in the casting.

If the core is too large, as in attempting too thin a casting, there is the danger of it touching the bottom of the mould and causing a hole there. Great accuracy is required to get a casting thinner than $\frac{1}{8}$ in., even in small work. The core shrinks considerably in drying, and this must be remembered when making the core-box.

Half-Cores. It is a great saving to make only half a core-box, viz :—one side only in which exactly half the core can be made. Two of these half-cores joined with a little glue form a complete core. This method is only suitable when the core is bi-symetrical.

Stop off. When only part of the pattern is required to be cast, the remainder can be stopped off. In some cases when a thin pattern has cracked and it is not convenient to repair it properly, a piece of wood is screwed on to hold it together. As this is not to form part of the casting, it should be left natural colour and marked very clearly STOP OFF.

Metal Patterns should be made if a large number of castings are required. If this is known beforehand, a double allowance must be made for shrinkage. The patterns are made of iron or brass, or for very small work type metal, or equal parts of tin and lead, but in any case they must be worked up quite smooth and bright. To enable the pattern to be lifted, a hole must be drilled in it, and plugged with soft wood. The first wooden pattern may in this case be more roughly made than usual and the extra work put on the metal one, which, if of iron, should have a coat of shellac varnish to prevent it rusting. In the case of a bright iron pattern, the varnish will adhere better if the iron is slightly rusted, and then cleaned up before varnishing.

Pulleys and Wheels. In consequence of the difference in the times of cooling between the arms and rim of a wheel, it is necessary to avoid very thin arms in proportion to the mass of the rim. This can be to some extent remedied by making the arms S shaped, and by using an odd number of arms, so that two of them are never exactly opposite. Patterns for wheel rims should never, unless of very small size, be worked out of the solid, but built up of layers of segments arranged to *break joint.* Pulleys having a groove cast in the rim for cord driving are made from a two-part pattern arranged with a print of good size all round. The core is made in a core-box that forms a segment only, as many as required to form the circumference being made.

Name Plates are made by using *Founders' letters*, which can be had in many sizes. They are like the tops of printers' type, but *not* reversed. They are easily attached to the pattern.

Repairing Patterns. Patterns should be examined when returned from the foundry and damages at once repaired, as they are often very badly treated by the moulders. Brass or iron plates and corners are useful for this purpose. Rub down with a stiff brush to get rid of any sand, then clean with glass paper and re-varnish if required. Knotting will do for filling cracks, but any larger damage can be stopped with a mixture of hard wax and whiting used hot, as it sets hard as soon as cold. The sawdust from hard wood mixed

with glue is a very good filling. However well made a pattern is, it will be found to have shrunk unevenly if stored in a warm place. Very little shrinkage occurs in wood lengthwise, but a great deal across the grain, so that joints that were smooth and flush when the pattern was made will require a good deal of trimming up. This can often be done with a file. The varnish will also have shrunk so as to show the grain of the wood.

Blacklead. Large patterns are sometimes coated with a paint made from blacklead and stale beer. This dries quickly in a warm place, and is easily polished to a smooth surface.

Lugs for Chucking. In making a pattern for work intended to be turned, it is necessary to consider how it is to held in the lathe—between centres or in the chuck—and to add the necessary parts to the pattern. An ounce of metal may save an hour's work. Some castings could not be turned without the extra lugs. They are especially useful on Castings for Model Steam Engines and similar small work.

Chaplets. When a core is supported from one end only, or is so large that there is a danger of its touching the mould, chaplets must be used. In its simplest form this is a copper tack with large head, stuck in a bit of wood, sunk so far into the sand as will bring the head of the tack to the right position to support the core. The wood is covered with sand, and the surface of the mould smoothed to shape.

Patterns for Thin Castings. The following method is often employed for thin mouldings and similar work. Plane up a piece of wood to the shape and size of the inner side of the required casting. Dress over this some sheet lead the thickness the casting is to be, and trim the edge. Using the lead, with its wood support as a pattern, mould one side, then, *leaving the lead in position*, remove the wood and make the other half-mould, working to the inner surface of the lead. Remove the lead, and the half-moulds when brought together will be the correct distance apart.

Carbon Cores. Round carbons as used for electric arc lamps are the best materials for cores, as they are quite round and stand any heat. Broken carbons can be had for a trifle, and often picked up in the street near the lamps.

Thin Castings. When a pattern is of very thin section to save weight in the casting, it must be strengthened, either by a rib in the middle or by flanges at the edges. The castings of Wringers or Mangles for domestic use are good examples of this class of work. They are so thin that it is wonderful that they keep whole until placed in the purchaser's house, yet as a rule they do not break unless unfairly used.

Makeshift Patterns for odd castings can be made by building up a rough skeleton of wood or light metal, and adding a mixture of wax and whiting applied hot, and smoothed to shape with hot irons, This can be quickly done for an emergency. The wax compo can be easily recovered by putting the pattern in a hot place until it is soft enough to remove. Hard wax can be used without admixture.

FIG 1

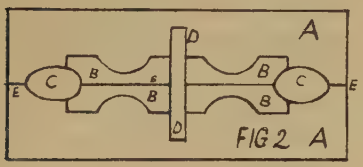


FIG 2 A

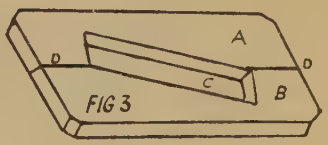


FIG 3

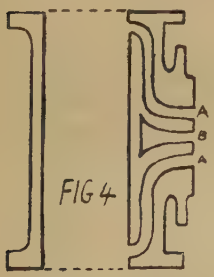


FIG 4

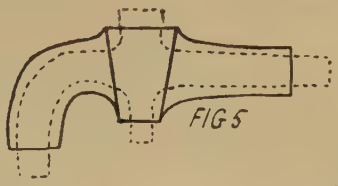


FIG 5

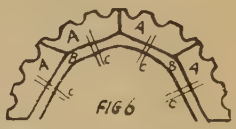


Fig. 1—The horizontal line shows the parting line for the various shapes of patterns shown on it. A, which is of square section and may be of any length is parted from opposite corners. B, round or oval from the exact centre of the swelling or belly. C, entirely in one half of the flask. D, from opposite angles to avoid a joint in the flat side. E, could not be drawn if the line were through the smaller diameter. F, section of a pulley, showing how it can be cast with a groove in, but the pattern must be in halves.

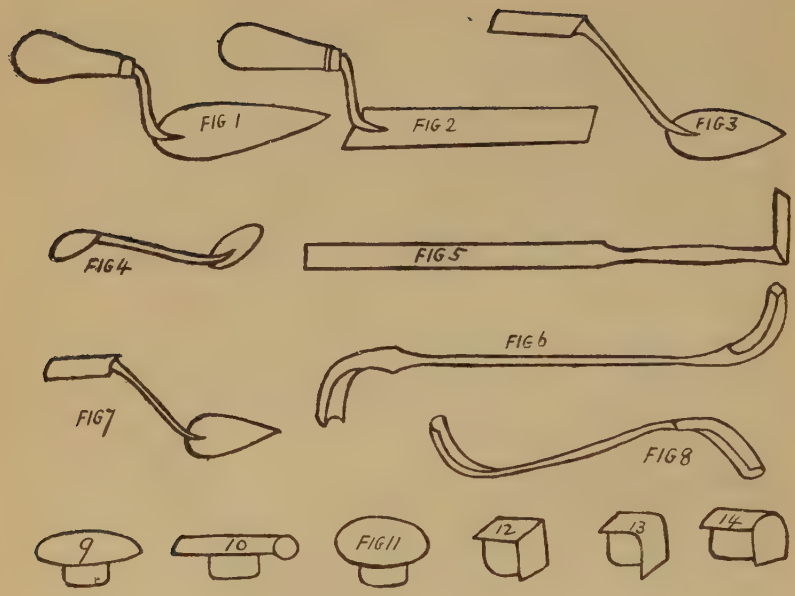
Fig. 2—A is the section of a flask with pattern of grooved wheel bedded in the sand. B, pattern in two parts. C, print which fits between the two parts of pattern and is replaced by a core of exactly the same shape. D, print and core for hole in casting. E, joint in the pattern and parting line.

Fig 3—Simple form of core box for use when a core is required with flat sides, or for short circular or square section cores. It consists of two pieces joined by dowels at D. The sand is rammed in the hollow C, and the parts on being separated release the core. The two parts must be held together by cramps while ramming.

Fig. 4—Section of steam engine cylinder. A being the steam ports, B the exhaust.

Fig. 5—Pattern for gland tap. The thick line being the pattern and casting, the dotted line shows the core. The prints by which the core is supported are not shown, but they are those parts of the dotted line that project beyond the thick line.

Fig. 6—Section of fluted column which could not be moulded from an ordinary pattern. AA are four pieces of the wood pattern forming half the column. B, an iron band to hold them together. CC, screws for fastening the wood to the iron bands of which there would be two or more. On withdrawing the screws, the bands are lifted off and the sections of the wood pattern can then be removed.



MOULDERS' TOOLS.

Fig. 1—Heart-shaped trowel made in three sizes.

Fig. 2—English flat trowel, it is also made taper. The Scotch trowel has a longer handle. 5 sizes from 5 x 1 to 7 x $1\frac{5}{8}$.

Fig. 3—Heart and square, a combination of shapes 1 and 2, but smaller. Five sizes from $1\frac{1}{2}$ x 1 to $3\frac{1}{2}$ x $2\frac{1}{4}$.

Fig. 4—Spoon tool, like a tea spoon and dessert spoon on one handle. Ordinary spoons can be used for the purposes.

Fig. 5—English cleaner—a long, thin, narrow blade, with a smaller one at right angles. Eight sizes from $\frac{1}{8}$ in. to 1 in. wide.

Fig. 6—Flange bead upset, both ends curved, one square section, the other semi-circular. Five sizes $\frac{1}{4}$ in. to $\frac{3}{4}$ in.

Fig. 7—Gate knife having a small trowel at one end, and a rounded plate at the other. The most useful tool for small moulding. Two sizes 2 x $1\frac{3}{8}$ and $2\frac{1}{2}$ x $1\frac{3}{4}$.

Fig. 8—Circular Bead Smoother, a smaller tool than Fig. 6, both ends of semi-circular section but different curves. 3 sizes.

Figs. 9 to 14—Small Corner, &c. Tools, each having a web for holding it while using. 9—"Bacca Box" smoother. 10—Safe end pipe smoother. 11—Egg Shape. 12—Square end. 13—Round end. 14—Flange corner smoothers.

See also Section "Brass Founding."

COPYRIGHT

How to Solder Gold, Silver, Aluminium, Copper, Brass, Tin, &c. Brazing, & Joints in Lead Gas Pipes.

By M. COLE.

* * * * *
* * * *

SOLDERING is the method of joining pieces of metal by a metal or alloy that melts at a lower heat. To solder it is necessary to **1—Clean the surfaces. 2—Place the parts in position. 3—Apply a Flux. 4—Place some solder so that it will flow into the joint. 5—Heat the parts to be joined. 6—Clean the joint.**

CLEAN THE SURFACES. Emery-cloth is usually enough, but if very dirty by scraping or even filing. The parts must be thoroughly clean or a good joint is impossible. Greasy surfaces must have special attention, not so much on account of the grease, but that an oxydised (rusted) surface will be usually found below it. Paraffin oil is one of the greatest difficulties in soldering goods that have been in contact with it, as it spreads in so thin a film as to be often unnoticed, yet prevents a good joint being made. Every trace of it must be removed, this can usually be done by burning off.

PLACE THE PARTS IN POSITION. If heavy this will be enough, but if light they are liable to move unless held with a pair of pliers, or tied with binding wire. Small work should be placed on an asbestos block and held down firmly. Delicate work and jewellery should be embedded in a block made of Plaster of Paris and Asbestos in equal parts, made into a paste with water, and then plastered over the work till nothing is seen except the part to be soldered. The mass must be heated till too warm for the hand to bear, the joint may then be made. The plaster is easily broken away.

APPLY A FLUX. This will vary with the solder used. For Gold or Silver Solder use borax. Rub a lump of borax on a bit of slate with water until it is like milk, then apply to the joint with a small brush. For other metals or where Fine Tinman's Solder is used, use either *Resin, Sal Ammoniac, or Spirits.* For **Brazing**, mix powered Borax with water to paste. **Resin** is mostly used for tin-plate or for lead work. **Sal Ammoniac** is used for joints in wires for electrical work, for which purpose spirits should never be used.

SPIRITS or SOLDERING FLUID. This is the most useful flux for all-round work and the easiest to use. To prepare: place some *Spirits of Salts* (Commercial Hydrochloric Acid) in a jar or bottle, and drop in bits of zinc till no more will dissolve (no more bubbles

of gas are given off) then add a little more zinc to make sure. It should be prepared in the open air as the fumes given off are very unpleasant, the bottle should not be corked during the process. If made in a room it will rust any steel goods there. For soldering zinc, use the acid as bought. When lead is soldered to lead, or to a tinned brass surface, resin should be used, but the surface of bright lead should be smeared with either tallow or butter, as a clean lead surface quickly oxydises if heated: a joint can then be made even if the resin is omitted. Olive oil or spirits is used for pewter, for which a special solder is made, melting at a very low temperature Some aluminium solders require a special flux which is supplied with them, others contain their own flux.

PLACE SOME SOLDER so that it will when melted, flow into the joint. The solder varies with the metal to be joined, for fine gold use lower grade of gold; for common gold or silver use *Silver Solder*; for copper, tin, lead, and zinc use fine *Tinman's Solder*; for Wiped Joints in lead pipe use *Coarse Solder.*

SILVER SOLDER. To make this take one part fine brass wire and two parts silver, and melt, using Borax as a flux. While soft, press the face of a hammer on it so as to flatten it, then hammer it out as thin as paper, making it red hot several times during the operation as hammering hardens the alloy. Cut up into bits as required. A very small quantity is enough for ordinary joints in Jewellery, &c. Don't use solder containing lead for gold or silver, as the lead will make it brittle.

TINMAN'S SOLDER is made by melting together one part lead and two parts tin, it should be poured out on a stone slab in strips. The lead must be melted first, the tin dropped in and at once pushed under the surface. If the tin is melted alone, most of it will be oxydised to a grey powder. A layer of charcoal, or flour which will soon be burned to charcoal, should be on the surface to keep out the air, or tallow could be used instead. For very small jobs, the tinfoil used for wrapping chocolates, &c. is very useful. At a pinch a good deal of solder can be got out of the joints of sardine tsns, &c. by holding them in a gas flame.

HEAT THE PARTS to be joined. There are several ways of applying the heat. Holding the job over the flame of a candle or gas is the *worst way.* The flame of a *Spirit Lamp* or *Bunsen's Burner* is very much better as they do not smoke the work, but the right way is to blow the flame on to the work by an ordinary *blow-pipe* or a *gas blow-pipe.* For some classes of work a *soldering iron* (copper-bit) is the most convenient.

SPIRIT-LAMP is a small lamp burning Methylated Spirits, provided with an air-tight cover to prevent loss by evaporation, and is useful for very small jobs, but for heavy work a blow-pipe torch is used, burning Benzoline or Naphtha. A good make-shift lamp for soldering can be made from a small sardine tin: break up a candle, cut the wick in four pieces, place together so as to form a short thick wick in the corner of the box, put in the wax or tallow and apply heat to melt, then light the wick, this will give a body of flame

large enough to melt a bit of gold or solder anything. **Bunsen-Burner** is a gas burner arranged to mix a certain proportion of air with the gas before burning, so as to give a flame without smoke. An upright incandescent gas burner, without mantle, will do for small jobs. **Blow-pipe** is a metal tube for blowing the flame on to the work. It should be light enough to be held in the mouth, with a little practice it will be found easy to keep up a constant blast, breathing through the nose at the same time. The best of all is the *Gas Blow-pipe*. The usual shape is a tube, bent at one end, the longer end being connected by a rubber tube to the gas supply, a length of thin brass tube is fastened to the larger one along the side and enters it at the bend, so that at the mouth of the pipe there are two tubes, the smaller one being for blowing through, the larger outer one for the gas supply—the smaller one being connected by a thin rubber tube to a mouthpiece—this will do any soldering or melt small quantities of gold, silver, or brass, or braze small jobs of iron or steel. For brazing it should be used with a pan of asbestos cubes; or for smaller work with Asbestos Blocks so arranged as to keep the flame on the work. A small flower pot broken lengthwise and laid on the block does well to keep the flame on the work. The large sizes are used with bellows worked by hand or foot for air supply. The flame of a blow-pipe, like that of a candle, is hollow. The hottest part is just beyond the point of the hollow—about the middle of the flame.

SOLDERING IRON or COPPER BIT. This is a lump of copper, fixed to an iron shank and wood handle. Before using, it must be tinned with solder at the working point. Heat the tool as hot as it will go without changing color if seen in the dark. Clean the end with an old file, then rub it on a bit of sheet tin on which is a bit of solder and some of the flux used, some of the solder will then adhere; re-heat as often as required to do the work, wiping clean each time before using. If care is used not to over-heat the tool, the tinning will remain on a long time, but if over-heated the tin in the solder will conver the surface to bronze and it must be re-tinned. The *Bit* should be at least 12-oz. weight for general use, some very small ones are made for jewellery and small jobs, but they are troublesome to use as they cool so soon. Some workers dip the *Bit* in the soldering fluid or *Spirits*, or wipe it on a rag saturated with spirits, others on o lump of Sal Ammoniac to clean it.

CLEAN THE JOINT. The joint must always be cleaned—if spirits, wash off with water; if borax, sulphuric acid and water will clean it—keep a brush for the purpose or scrape clean.

RE-TINNING KETTLES, &c. Iron and copper pans, &c. have a thin layer of tin to prevent rusting or copper poisoning. This is worn off in use. To re-tin, clean the surface with sand, or if necessary emery cloth until quite bright, wet well with soldering fluid and put in some tin (*real tin, not solder*). Apply heat until the tin melts, then spread it all over with a mop or rag at end of a stick.

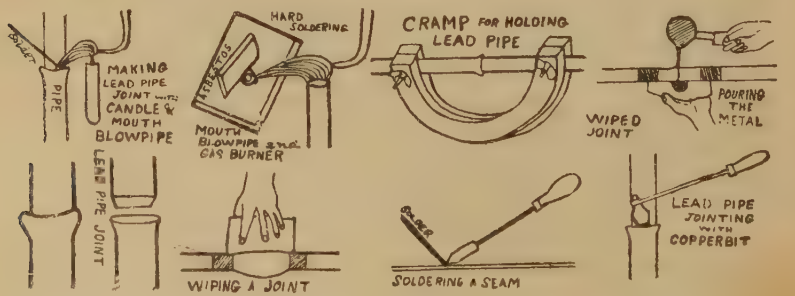
In **Soldering Aluminium** it is necessary to bear in mind that upon exposure to the air a slight film of oxide forms over the surface and afterwards protects the metal. The oxyde is the same color as

the metal, so that it cannot easily be distinguished. The idea in soldering is to get underneath this oxyde, whilst the surface is covered with the melted solder. With the following proceedure quick manipulation is necessary :—Clean off all grease and dirt from the surface of the metal with a little benzine. 2—Apply the solder with copper-bit, and while the melted solder is covering the surface of the metal, scratch through the solder with a little wire brush or knife blade. By this means you break up the oxyde on the surface of the metal, underneath the soldering, and the solder, containing its own flux, takes up the oxyde and enables you, so to speak, to tin the surface of the aluminium. After this, the soldering is quite easy. A Special Solder is sold for the purpose.

TINNING AND SWEATING. When soldering iron it must be tinned or given a thin coat of solder before attempting to solder it to any other metal. When two tinned parts are held together and heat applied it is called sweating them. The tinned surfaces uniting to make a joint. Soldering fluid should be used.

BRAZING is merely soldering iron or steel with brass instead of solder, but a better joint is made if silver solder is used, and is worth while as silver is so cheap now. The brass is in the form of either fine wire or filings—the special spelter should be used. For joining a band-saw or other such article, the parts must be fastened so that there is no chance of their moving ; the ends must be tapered and held together with binding wire, a special pair of tongs, extra heavy ends, made red-hot, then clamp the part and the heat of the red-hot ends melts the brass—this is much better than gas for the purpose. Very small articles, as keys, can be brazed by putting on a lump of red-hot iron, the heat of which will melt the spelter.

HOW TO MAKE A JOINT IN LEAD GAS PIPE. The two pipes to be joined must be fixed so that they will not move during the soldering. The lower one must be expanded at the end into a cup shape with a pear-shaped tool (turnpin) and the part to be soldered scraped bright and greased with tallow ; the upper one is then scraped and greased and fitted into the cup of the lower one, some crushed resin is then applied which the tallow will held in place ; then with a stick of solder held in the left hand against the joint, the blow-pipe flame or copper-bit (hatchet shape for this job) applied will cause the solder to run into the joint.



See also Sections—"Wiped Joints in Lead Pipes" & "Cycle Brazing"

COPYRIGHT

METAL RIVETTING

Hot and Cold,

From Jewellery to Steam Boilers.

By M. COLE.

* * * *

Rivetting, being such an easy and effective method of joining metals, was in use from the earliest times of metal working. It was the first known method, long before soldering, brazing, or screwing were invented, and until the introduction of machinery for making screws, rivetting took the place of the modern screw bolts on account of its cheapness. The principle points to be looked to in rivetting are: 1—The rivets should be as soft as possible so as to spread easily, well annealed iron for large work, annealed copper for smaller, and brass for smallest work. 2—The holes must be exactly opposite each other, or the rivet will bend sideways. 3—The plates must be in close contact, or the rivet will expand between them, forcing them apart instead of bringing them closer together. 4—Rivet must be suitably proportioned. The diameter should, where possible, be rather more than the thickness of the joint, and the length such that the part projecting is about equal to the diameter of the rivet, as this forms the best proportioned head. 5—The surfaces of the plates must be smooth and free from burr round the holes as this would prevent close contact within the joint. 6—The rivet must fill the hole. This is very important, as if there is much space between the rivets and the sides of the hole, the expansion of the metal will have to fill the space first, reducing the quantity left for forming the head. It is of course impossible to get rivets to fit like machine parts, but it is important to keep the space as small as possible and make allowance for it in the length for forming the head.

COLD RIVETTING.

Small Work, such as toys, jewellery, fancy leather bags and purses, require very small rivets, and ordinary pins will be found just the right material for such work, as few rivets are required smaller than the smallest sized pins used for fastening the ends of ribbon in rolls, while the largest size pins are fit for quite strong work. If these are too thin, some small brass nails are sold by ironmongers called *brass pins*. These are in several sizes and will do for work up to two thicknesses of $\frac{1}{16}$ sheet metal, and are suitable for small copper model steam boilers. Any work requiring larger rivets than these cannot be classed as small. Before using any kind of brass pins as rivets, they must be softened by heating to red heat. and at once quenching in cold water. On the underside of the head of each pin will be found two small webs or ridges left by the joint in the dies used in forming the pin head, these must be filed off. The pins are all much too long for the work to be joined, but this is an

advantage, as in small work a rivet the exact size required would be too small to handle with the fingers. Use the pin full length, and when all is in position, hold down the parts to be joined, and with end nippers cut off the superfluous length and rivet down with a light hammer. It is scarcely necessary to add that the head of the pin must be resting on some metal object, the weight of which must be too great to be moved by the blows of the hammer. If the hammered end of the rivet is seen, it may be rounded by using a punch having a counter-sunk hollow in its face, though this is seldom required for very small work. In some cases the parts of the article itself form the rivets, they then only require hammering down. Locks of all shapes, except those of the best quality are so rivetted together. To open such a lock, the burr is filed off the side of the projecting metal forming the rivet, but the parts can be rivetted down and opened several times. Rivets can be made from wire such as those of Platinum used for the contacts of electric bells. Select a piece of iron of thickness equal to the length of the required rivet. Drill a hole through it to just fit the wire used. Cut off a length of wire long enough to form both body and head of the rivet, and place in the hole on the plate resting it on some metal. Give the projecting bit of wire a smart tap with a light hammer to spread it, repeating the blows until the head is formed. The rivet can be pushed out of the iron plate from the back.

China Rivets (so called) used for repairing glass and china, are not really rivets but staples, as they do not go through the work to be joined. If it is desired to use real rivets, the inner ends cannot be burred up as in other work, so they must be formed by using a bit of soft solder put on with a soldering iron. They are made from ordinary hard iron wire, and may be tinned before using to prevent rust or coppered by immersion in a solution of Copper Sulphate. A hard brass wire answers well though seldom used for this purpose.

Rivetting Spectacle Frames. Some forms of eye-glasses and spectacles without frames have fittings put on by screws passing through holes in the glass. These screws, being very small, are easily lost. They may be replaced by a rivet made from a pin, but it must be a good fit for the hole and be softened, with a little care there is no danger of breaking the glass. See that the head of the pin rests on some solid substance and that the glass does not touch it.

Eyelets are hollow rivets and used the same way, but with a special tool to close them properly. They usually require a washer as the burr formed is not large enough to hold against much strain.

Holes in Leather for rivets are punched, but failing the proper tool, one can be made from a bit of brass or iron tube, filed to a sharp cutting edge at the end on the outer surface. This makeshift tool should be used by pressing it down and at the same time giving a twisting motion to it, as it will not bear hammering like a proper steel leather punch.

New Rivet in Pocket Knife. If the rivet is broken or worn, or a blade has to be replaced, the old rivet must be removed. Make a cutter by breaking off most of the blade of an old table knife, leaving a couple of inches on the handle. Resting the knife on its back on a firm support, insert the cutter between the blade and the scale,

the edge resting on the rivet. A smart blow with a hammer will cut the rivet. After cutting at both sides of the blade, the broken rivet is easily removed. Make a new rivet from a nail or piece of steel wire to be a good fit for the holes in the handle, but easy fit for the blade hole.

COLD RIVETTING LIGHT SHEET WORK.

Stove Pipes and other metals of similar thickness are put together with iron rivets used cold. In such rough work as this, the holes are seldom punched by a separate tool, but the rivet is made to do the work of the punch. The easiest way is to place a rivet under the two thicknesses of metal, and a bit of hard wood on top. A smart blow with the hammer will drive the rivet through, if the metal is thin. If too thick for that, it will at least make a deep dent in it. If again placed in position, and the hole of the rivetting set placed over it, a smart blow of the hammer will send it through, and the projecting end can be rivetted down, being careful that the two thicknesses of metal are held down during the process, otherwise the rivet may spread between them and force them apart, instead of forcing them together. The hollow in the rivetting set is then used to give a finish to the rivet head. For thicker work the hole is either punched or drilled.

For large holes in thin metal the end of the punch may be at an angle, so that only part of the punch is in action at the commencement of the cut, and gradually more edge is used, like shears with circular cutting edges.

HOT RIVETTING LARGE WORK.

Steam Boilers, Girders, and other large work, are done with red hot rivets, the contraction of the rivets in cooling drawing the plates together with great force. A disadvantage of the hot rivet is that the metal is so soft that it is forced into any cavity there may be between the plates, and if the holes are badly punched, or the plates not flat, the hot metal will in the hammering get between them and force them apart in some cases instead of bringing them closer. Boiler work is now drilled. End holes having been made, the plates are bolted together and the holes drilled through both plates at once. Girder work not being required to be so accurate, the holes are punched, so that they are usually a bit out of truth, though with careful marking not far out. The plates having been put in position and fastened by bolts through end holes, the holes are brought true with a taper reamer, as the punching always leaves the hole slightly tapered. When rivetting is properly done and the surfaces clean and smooth, they are in such close contact that a section through the joint looks like solid metal, only a hair line showing where the joint is. Girder work is, of course, not so exact as this.

Punching the holes is done at the works by machines run by power, but in working out for repairs, &c., and in small shops they have to be drilled. Metal of moderate thickness can be punched in a fly press with either wheel or arms acting as a fly wheel, and a quick screw. In this the power is stored in the wheel or arms during the travel of the screw, and is given off when the punch penetrates the metal. Another form—a very slow screw is used, in which power

is gained at the expense of speed, and moved by lever slowly forces the punch through the metal. This form has the advantage of being very portable and light compared with the fly press, and is capable of doing a large range of work. For hand punching of small holes in thin plate, the tools are simply punch and bolster or die. The punch must in all cases be of good quality steel, and the cutting face either flat or slightly hollowed. The die is also of good steel and a good but easy fit for the punch, and the edges of both of them quite sharp so that there is a good shearing cut. If the punch is too small for the die, or the edges are not sharp, the metal is pushed out instead of a clear cut. The less play there is the cleaner the cut will be. If the punch is not accurately set in relation to the die, they will probably catch at some point and spoil both. In hand punching the position of the punch on the plate in relation to the bolster below it has to be guessed, so that it is not true cutting but just getting the punch through as well as possible and at the best is only botch work. The punch is much smaller than the hole in the bolster, which in many cases is only an old nut. Good punching cuts the hole cleanly, bad punching tears it. Drilled holes leave the metal 10 per cent stronger than punched ones.

Rivetting is usually done by two men at the hammers, a third one to hold up, and a boy to hand the rivets. The boy inserts red hot rivet in the hole, the holder-up placing the *dolly* or back hammer under the head, and the top of shaft resting on a loop, pressure at the end causes the dolly head to have enough resistance to the blows of the hammers to enable the top end to be closed without driving it back through the hole, which would be the case if the pressure at the back is not enough. When closed, and while the rivet is still hot, a snap is placed on the new head and a couple of strokes of a sledge hammer gives the required neat finish, but does not add to the strength of the rivet. Two or more rows of rivets are used where strength requires it, and to avoid weakening the plates by putting the rivet holes too close together. Double rivetting (two rows of rivets) leaves the plates two-thirds the original strength, while single row leaves it little more than half. Three rows are usually considered to be equal to the whole plate. If the strength of a plate is 1000, that of a double rivetted joint is about 700, and single rivetted joint about 560. Flush top or countersunk rivetting is weaker than the headed work, as some of the metal of the plate has to be removed to make room for the tapered head of the rivet. Punching the holes weakens the plates more than drilling them, but in any case if a line is drawn through the centres of a row of holes, the metal removed must never exceed 25 per cent.

Removing Old Rivets. In large work the projecting head is cut off with a cold chisel, in smaller work it is filed off, the rivet can then be punched through with a punch, which should be nearly as large in diameter as the rivet. If too small it will slip to the side. The work, if small, may be supported on the end of a piece of iron pipe, slightly larger than the outside of the rivet head. This will prevent the work being bent out of shape.

Caulking the edges of the plates has to be done in all work that has to stand steam or water pressure. The tool, a thick ended chisel

or drift is held against the exposed edge of a plate where it overlaps another one, the flat of the tool resting on the latter, and struck with a hand hammer, which burrs or expands the plate edge, and if properly done makes the joint steam and water tight.

Leather Rivetting is mostly in use for leather fire hose and buckets, and is done with copper rivets and washers. To get the hose water-tight, the rivets are close together and the washers large so that the edges of the washers have but little leather unsupported by the metal. If the leather is pliable as it should be, the inner edge is pressed against the other part by the pressure of water, so much as to act as a valve. In rivetting, a short length of hard wood faced with iron is placed on the strip to be jointed, and a start made at one end, after a few rivets have been closed the block is removed a little further and so on until completed. Leather buckets are made water-tight by a coat of paint at the joining, as they are not intended to be flexible like the hose. Leather belting for machinery is often rivetted together, some of the belt fasteners having rows of teeth on the under surface are really rivets, being placed on the joint and hammered down, the teeth rivetted over, the ends of the belt being brought together to form a butt joint. Where the ends overlap, the patent copper rivets known as "*Bifurcated rivets*," will be found very useful as they are strong and quickly used, requiring no other tool than a hammer to fix them.

Rivetting a Model Steam Boiler.

A Model Steam Boiler is the best test of skill in rivetting small work, as a strong close joint is required to stand the steam pressure. The material should be either sheet copper or brass, the latter is mostly used, as it has a better appearance when polished, and is easier to bore and less liable to kink in working. For a boiler six inches diameter, it should be $\frac{1}{16}$ thick and of good quality, and should never be made of old metal, but always of new. This will stand a working pressure of 50 to 60 lbs. if double rivetted, and 40 lbs. for single rivetted seam if well made, but it must be strengthened with rings for all parts cut out, as the dome, manhole, &c., which weaken the plate. This thickness of plate will not do for larger sizes as the thickness must increase with the size of the boiler. Before commencing to work the sheet metal, it must be made red hot, and quenched in cold water to soften it. The sheet brass must now be bent to tubular shape with a wood mallet on an iron pipe or rod, though it is better to have this done in the rolling machine used by tin-plate workers. It must be cut large enough to lap over $\frac{5}{8}$-in. for a double rivetted joint, and left of such shape that it springs open to a larger diameter than the finished tube. It is now tied with wire to bring to exact diameter of the finished tube, and cramp together by any suitable means. A good way of doing this is to use two lengths of wood, say six inches longer than the work, one inside the other outside the lap, and fastened together at each end by either screws, bolts, or cramps. Then to ensure close contact, put wedges between the outer piece of wood and the metal so as to bring the two parts of the lap close together. The next thing is to solder the joint. This has to be done on account of the metal being too thin to drift up

with caulking tools as in large boilers. The solder forms a kind of packing, and is not intended to strengthen the joint, as it will be quite soft when the boiler is under steam pressure. It would be unsafe to use a boiler with steam if the joint were only soldered, though some are made with brazed joints, and others of seamless tubing. The parts to be soldered must be thoroughly cleaned by scraping or with emery cloth, and then tinned or given a thin coat of solder, using a copper bit (soldering iron) and spirits or soldering fluid as a flux. All superfluous solder must be wiped off with a cloth while hot, so as not to leave too much inside the seam. This is done before the cramps are put on. The parts are now soldered together using plenty of solder, which will find its way into the joints following the spirits and all left outside is wiped off. This soldering can be done either with the blow-pipe or copper-bit, after the parts are in the cramps. As the piece of metal has a large surface, it must be made hot before soldering or will take a long time to do, as it will draw the heat from the copper-bit. When the solder is set and the metal cool, remove the cramps and proceed to the rivetting. For this job the rivets should be $\frac{1}{8}$ diameter, and if of brass should be softened by making red hot and quenching. If there is a web on the underside of the head, it must be removed with a file. If the rivets are too long, it is best to insert them of full length and cut off the superfluous part with end nippers as these small rivets are awkward to handle. Mark the places for drilling with compass or dividers, if for two rows place them $\frac{1}{4}$-in. apart, and $\frac{1}{2}$-in. between the rivets in each row, but let the two rows *break joint* or be zig-zag, not opposite each other. Drill the holes with any suitable drill, then clear off any burr formed on the inner side of the tube or it will prevent the rivet head getting a fair bedding on the plate. As we cannot get a holder up inside so small a job, a piece of heavy bar iron is used or better still a tin-plate worker's *Beak Iron*. The rivet being inserted in the hole from inside, and some support to rivet on, hammer up the head of rivet with light blows, not all in one place but so as to form a head, then to give it a neat finish use a small rivetting set. This is easily made from a bit of $\frac{1}{4}$-in. iron rod. Drill a hole in the end with an ordinary drill so that it makes a conical depression. As only a small number of rivets are to be headed, there is no need to make a steel tool.

Note—It is very important that the rivet be a good fit for the hole. It is best to drill the hole rather smaller than required, and open it a little with a broach.

Limit of Cold Rivetting. Cold rivetting to be effective must be employed on small rivets only. The enormous amount of force required for cold work may be seen from the fact that it requires a force of 30,000 pounds to close a $\frac{3}{8}$in. rivet properly, so as to fill the hole and form the head. The same amount of force (about 14 tons) is required when it is done with hammers, and the great number of heavy blows required to produce this force will harden the rivet (before the work is done) so much as to make it brittle. Cold rivetting with hammers should not be done with larger rivets than $\frac{1}{4}$-in. where strength of joint is required, and never for work that has to stand steam pressure. Copper rivets can be used up to almost any size.

Machine Rivetting. The earliest Rivetting Machine was a steam cylinder, the piston rod of which pressed on the rivet, but this has been superseded by Hydraulic and Pneumatic Machines. The former closes the rivet by a steady pressure, while in the latter a series of blows is given by a rapidly moving piston (having a hammer head) working in a cylinder by air under great pressure, and has the advantage of being portable. The air is conveyed to it by a flexible pipe from the compressor.

Why Rivetted Joints fail. The following are the main causes of failure:

1—The rivet is *sheared* or cut in two by the edges of the plates acting like shears, the rivet being actually cut not torn asunder.

2—The plates are torn between the rivets or in the part surrounding the head.

3—The rivet or plate, or both of them are crushed out of shape, so come asunder.

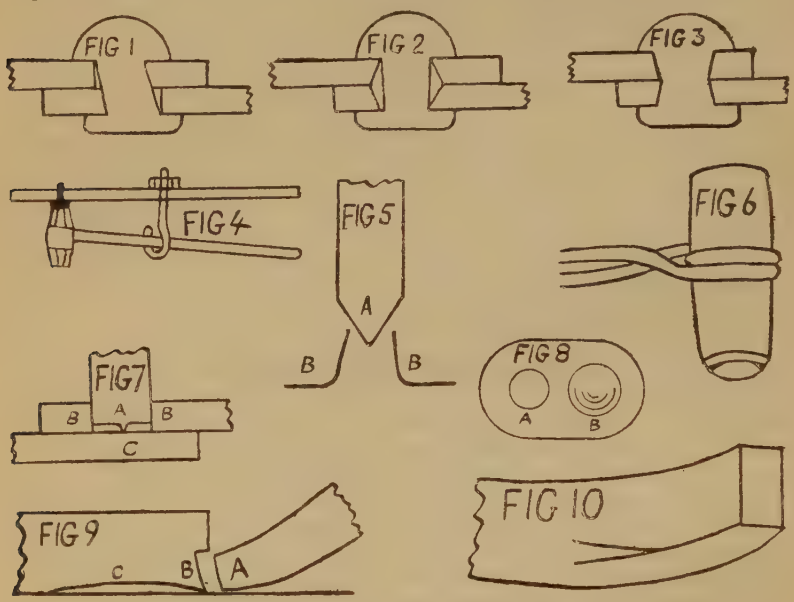
4—The plate tears between its edges and the rivet hole.

TESTING FOR LOOSE RIVETS.

There are two methods of detecting loose rivets, by sound and touch. Using a light hammer of say 1-lb. weight and tapping gently, the sound given by a well fitted rivet differs so much from one that does not fit the hole or is loose, that it is easily detected. The sound also varies with rivets holding only two plates, from those holding several plates. The latter are apt to sound loose on account of their length, and from the difficulty of filling all the space in the holes of all the plates, so though the rivet may be well bedded under both the heads, it may not and probably will not fill the holes in the plates, thus giving a sound like a loose rivet. Another way is to place the hand on the head of the rivet, and gently tap the made head. If loose the vibration will be felt. Rivetted work that is countersunk on both sides is difficult to test, and is done by pressing a finger on the rivet and tapping the plate near it. This should be done at both ends of the rivet. It is much easier to detect a loose rivet in a drilled hole than in one that has been punched, as thr roughness of the latter often presses on the latter and prevents its giving the warning sound when tapped. It is easier to detect looseness by tapping the original head of the rivet, than the one made by closing it. Tapping the head sideways is better than end taps. One way of detecting bad rivetting is to notice how long the rivets take to cool. If all are equally heated, those that are well fitted will cool much quicker than those that are badly done. In the former case all the surface of the rivet touches cold metal, while the bad ones miss contact at many places, so cool more slowly. Dirt or slag from the forge fire will also cause bad work by getting between the rivet and the plate. Another cause of bad work is when the hammering is at once directed to forming the head, instead of first forcing the rivet to fill the hole, then attending to the head. In fact, attention to this and avoiding burrs round the holes are the secrets of good rivetting.

Proportions for Rivetted Joints of Steam Boilers, &c.

Thickness of Rivet	$\frac{3}{16}$ in.	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.
Diameter of Rivet	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	1
Length of Rivet	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{5}{8}$	$2\frac{1}{4}$	$2\frac{3}{4}$
Distance apart	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{1}{2}$
Lap of Plate	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{3}{4}$



EXPLANATION OF DIAGRAMS.

Fig. 1—Shape of rivet when the holes in the plates do not match.

Fig. 2—Punched plates fitted so that the larger sides of holes are in contact, forming a ring of triangular section to be filled by the body of the rivet.

Fig. 3—Correct form of rivet in section.

Fig. 4—Method of swinging holder up hammer or dolly.

Fig. 5—Eyelet shown in section, for leather work, closing with punch.

Fig. 6—Snap or set for rivet head.

Fig. 7—Centre Punch for marking centre for drilling hole in plate C, it fits in hole in plate B, which serves as guide for punch.

Fig. 8—Rivet set for cold rivetting. The hole A acts as a die when the hole is made by a rivet acting as a punch, it also enables the two plates to be brought into close contact. B is a countersunk hollow. It is used for giving a finish to the head after it has been formed with the hammer.

Fig. 9—Caulking the edge of a boiler plate. The tool A forms a groove B, presses the metal on the other plate, and closes the hollow C.

Fig. 10—End of Caulking tool, of which there are many shapes. The one shown is much curved for getting at awkward places, usually they are almost straight.

COPYRIGHT.

How to Grind and Set Edge Tools.

By M. COLE.

* * * * * *

Stones used for Grinding, &c., consist of small particles of Silica (Quartz) naturally cemented into a mass known as sandstone. The grains vary much in size, so that the stone is of fine or coarse grain, suitable for rough grinding or fine oil stone. The grains of Silica are harder than steel, so that they will scratch that metal if rubbed upon it, but they are easily displaced. A stone that will grind hardened steel can be scratched by soft iron, which does so by displacing the grains of silica. When a grindstone is revolved at so high a speed that the centrifugal force so produced overcomes the adhesion of the particles, the stone bursts or flies to pieces, a frequent cause of accident in grinding shops. There is a limit of speed beyond which it is unsafe to revolve a grindstone, or even an iron fly wheel—cast iron fly wheels often breaking and projecting the fragments to great distances, if driven at too high a speed. Any flywheel can thus be broken, but stones are even more liable to this accident on account of unseen cracks which may exist. A small stone must be revolved at a greater speed than a large one to get the same surface speed, but as the stone gradually wears smaller, it is usual to replace the driving pulley with a smaller one, getting greater speed to make up for the wear of the stone.

Sandstone is softened by being constantly wet, so that if a trough is used to contain water, and so fitted that the stone is partly immersed, as the stone usually comes to rest in the same position, one side will be softer than the remainder and wear much quicker, the stone soon becoming of irregular shape instead of circular. If the stone is kept in the open, uncovered, the sunshine will harden the part exposed to it, giving the opposite effect to that produced by the water bath. Grindstones are usually used wet for the following reasons: friction produces heat, and the friction of the metal on the stone if driven at a high speed would heat the edge of the tool enough to draw the temper. The water also helps to keep the stone clean by preventing the fragments of steel ground off clogging between the grains of the stone. A wet stone cuts quicker than a dry one, but the surface left is not so fine as in dry grinding, which is sometimes used for finishing such work as razors before hardening them, though the dust given off is very unhealthy. Oil is used on the finishing stone for the same purpose, of allowing the tool to slide more easily on its surface, while the grains of silica project through the film. The quality of the stone required depends entirely on the work to be done, just as various cuts of files are required. Artificial grindstones are made from the grit of grindstones cemented by suitable means into shape.

Mounting a Grindstone. The old method of fixing a stone to the axle by wooden wedges is a dangerous one, as the wood driven in tightly when dry, expands when the moisture reaches it, and is a frequent cause of cracked stones. A much safer plan is to use lead, which is poured melted into the space between the axle and the stone. It must then be drifted up with a blunt chisel so as to fill the hole, as it will have contracted in cooling. The lead should be poured at as low a heat as it will flow at. Melted sulphur or Portland cement are good substitutes for lead. For very large stones wedging is best as it allows a little adjustment, and the wood can be kept dry. The axle may run in iron bearings. A good fit is not necessary as it cannot be maintained, the grit invariably getting into the bearings.

Water Supply. If a trough is used, it should be hinged at one end so that when not in use it can be let down a few inches and so prevent the stones being partly immersed when idle. A safer way is to fix a can of water so that it will drip on to the stone. For small stones, a bit of sponge or cloth fixed so that it touches the stone and can be kept wet, answers very well.

Speed of grindstone should be as great as can be got by turning crank or handle, the fatigue of the operator will be found an excellent automatic preventative of too high a speed. For stones run in a treadle lathe or similar mounting, the speed should be low enough to allow the tool to rest against the surface continuously. If at too great a speed it will be found impossible to work the treadle, unless the grinding is intermittent. Emery wheels are usually marked with the speed with which they may be run with safety. Some makes of wheels are safe to run at a speed that would be dangerous with a wheel of another make.

Keeping Surface Level. This is a very important matter. When gouges are ground on the same stone as flat tools, it is difficult to keep the surface level. If the stone is broad enough, a groove may be kept near the edge, if narrow it is as well to keep one at the side near the edge. The face of a grindstone can be turned true when required with an old file or bit of iron pipe, turning frequently to get a fresh cutting surface, which displaces small fragments of stone.

Oil Stones are of many sorts, but it should be remembered that the finer the stone, the less metal is removed at each stroke, and a good cutting edge can be got with a quick cutting stone. The finer and slower ones are sometimes used for producing a polish rather than a cutting edge. Usually wood-working tools do not require so fine a stone as metal cutting tools, such as gravers. Every oilstone should be mounted in a wood block, with a cover to keep the dust off it. It is a good plan to fix a bit of hard wood at each end of the stone thus lengthening it say two inches at each end. The tool travelling from one block of wood to the other, will traverse the whole length of the stone, so preventing it wearing hollow. Some light colored oil stones have streaks of a darker stone running through them—these should be avoided as the dark part does not wear evenly with the lighter part.

Lubricants. An oil stone is generally used with oil, Neatsfoot or Olive being the best. Thin this with paraffin—never use turpentine for the purpose as it causes the oil to dry quickly. Glycerine is a

good substitute for oil, and is less liable to thicken on the stone. Some oilstones work well with water.

Cleaning Oil Stone. If an oilstone is neglected the oil dries on it, forming a hard skin, which prevents any good work being done on the stone. It can usually be cleaned off with Paraffin or Petrol, or may be boiled in a strong lye (soda or potash dissolved in hot water). Some of the old oil will have sunk below the surface of the stone, this takes some time to loosen again. It is often quicker to put a fresh surface on the stone.

Hollow Face. This is caused by using the middle of the stone more frequently than the ends. When several persons have the use of one stone it is sometimes advisable to fasten a bit of wire round the middle of the stone as soon as it shows a little hollowness, so compelling them to use the ends.

Levelling the Stone. In spite of all care, oil stones will wear to an uneven surface. To bring it level again, clean off all trace of oil, and rub on a flat stone with plenty of water. A sheet of rough glass paper placed on a level surface does very well. If the back of the paper is chalked well it will not slip about. If the stone is a very hard one it may be necessary to use emery, either in powder or cloth, starting with coarse and finishing with fine grade. The stone must lie level on the workbench and be firmly supported, If not, it rocks with each movement, and good work cannot be done with it. Gouges should be set on a stone kept for the purpose, or it will be impossible to get a good edge on the flat chisels, &c. Sometimes the stone is so mounted that either side can be used, in such case one side can be kept for round or pointed tools.

Emery Wheels, when solid, should be run at the highest safe speed, but it will be found that an emery wheel, even of small size, takes a great deal of power to run, and only small ones should be driven by foot power. An emery wheel should never be mounted in a good lathe, as some of the dust is sure to find its way into the bearings. The special grinding and polishing lathe heads are very cheap, and the same one will carry a polishing mop. If, however, there is no alternative, the wheel can be mounted on a spindle carrying a pair of cheeks, such as can be had ready made for the purpose. A leather washer should be placed each side of the wheel to get a good grip.

Direction. The top of an emery wheel should run *from* the user. The reason for this is, that if any small object should get between the face of the wheel and the rest when the wheel is running towards the user, it would by suddenly checking the wheel, cause it to burst. Most accidents with emery wheels are due to this.

Wet Grinding. In grinding edged tools, the wheel should be kept well wetted, or there is great danger of burning the edge, or at least of drawing the temper. This applies mainly to solid wheels when run at high speed.

Emery Faced Wood Wheels are very useful and easily made. The wheel is built of wood and faced with emery by glueing the surface and rolling in the emery powder, which, when dry, adheres strongly enough for the purpose if run at a moderate speed. Another way is to glue emery cloth on the wheel, being careful that the

joint laps over so as not to catch the work. The flat side of the wheel may also be covered and is useful for polishing.

Coarse or Fine Emery Wheels can be had suitable for a variety of purposes, from coarse ones used instead of files for removing a quantity of metal, to the very fine ones that will finish a tool nearly as well as an oil stone. If overheated, wheels are apt to glaze, especially some makes. Where only one wheel is used for grinding gouges and chisels, a groove can be made in the face for gouges, and flat tools ground at the side of the wheel. For irregular shapes a pewter wheel can be used, fed with oil and emery powder.

Artificial Hones are to be had made from grindstone dust cemented together to a block, also emery blocks fine and coarse. These should be avoided if it is possible to get the proper oil stones. Artificial grindstones when of good make are, however, superior to natural stones for fine grinding, though somewhat higher in price. The grit is very even and the texture more regular than the natural stones. They are less liable to wear out of shape or to soften in the water.

Makeshift Stones and Hones. Circular grindstones are of comparatively recent date, and even to-day are unknown in many parts of the world, where workmen manage to put a good edge on tools without them. Rubbing on a flat stone will sharpen a tool quite as well as holding it against a revolving circular one, though the process is much slower.

Substitutes for Oil Stones are specially useful for insides of gouges, &c., and are slips of zinc bent to required shapes and used with oil and emery, they are largely used also for beading planes, &c. A piece of any very hard wood or of bull neck leather can also be used for the purpose.

HINTS ON GRINDING AND SETTING.

Forge thick—Grind thin, is a good motto, so with new tools see that they are left large enough for the skin of steel (which has been partly de-carbonised in forging) to be ground off. The extra labour will be well repaid by the superior quality of the finished tool. Do not expect the oilstone to do the work of the grindstone, and do not put off grinding too long. Setting should be done frequently, a few strokes on the oilstone every few minutes is more economical than using a tool after the sharpness has gone just "*to save time.*" Dull tools don't cut quickly and do not leave a clean surface. When the tool has been ground to the correct angle, it loses a portion of the ground surface every time it is set, until it gradually becomes either a curve or a series of ridges, instead of a flat surface.

Wire Edge is formed on a cutting edge in setting or in grinding, by the edge becoming so thin that it is bent over the other side instead of being worn away. Though called wire edge, it is really in the form of very thin curled sheet metal. It must be removed either by drawing the edge across a bit of hard wood, or by placing the blade on the oilstone so that the back lies flat upon it, and giving a few strokes while in that position. The setting can then be continued, but so long as the wire edge remains the chisel will not cut. All flat tools, such as chisels or plane irons, should have a few

strokes on the wrong side during the process of setting, without waiting for the wire edge to form, but being careful that the tool lies quite flat on the stone. A very acute angle gives the best cutting edge, but renders it so much weaker. The razor is an example of a very small angle, the axe of a very large one at the edge. The one is required for great keenness the other for strength.

Plane Irons should be slightly curved at the edge to prevent the corners digging into the wood. Jack planes are most curved, trying planes least so. In grinding a plane iron, let the stone run towards the tool. It will make a little mess that way, but gives the best edge, and less liability to wire edge. If the stone is flat, it is merely a question of holding the tool steady, but if irregular on the face, the tool cannot be level edged. The larger the grindstone, the nearer a flat surface the ground part will be, while a small stone gives a hollow surface which, however, is easy and quick to set.

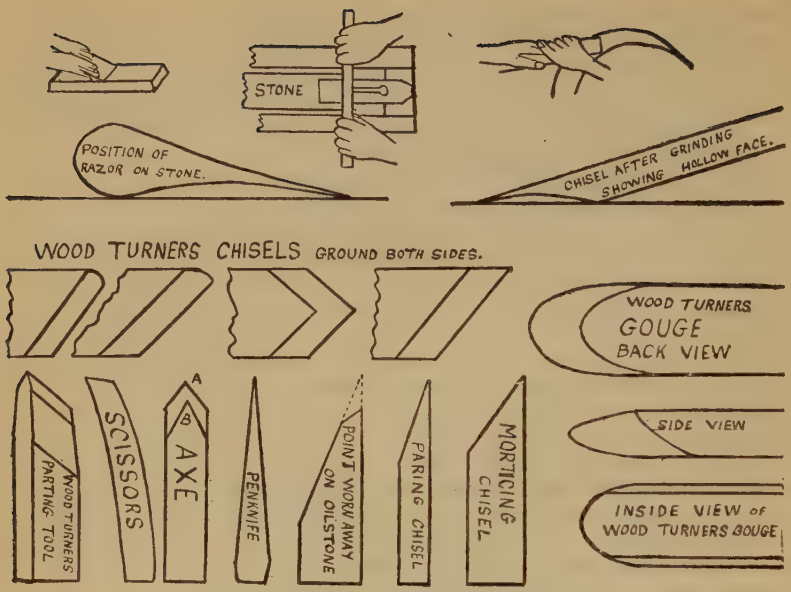
Gouges. In grinding these, let the stone turn away from tool, and give half a turn too and fro all the time the tool is on the stone. Do not grind a bit and then turn a little, or the result will be a lot of flats instead of a continuous surface. When setting a gouge, the tool is moved on the stone just as the chisel is, but at the same time a turning movement must also be given to it, to and fro, otherwise a series of flat surfaces will be formed. A groove in the stone will make this much easier. There is a little knack in this but it is soon learned. The inside must also receive a little attention to prevent wire edge, just as with a chisel. Slips of stone or zinc with emery are used for this.

Tool Ends require to be put on the grindstone, especially gouges, or they do not preserve their proper shape. Chisel ends also are liable to become out of shape with their sides.

Wood-Turning Tools, except gouges, are ground on both sides, not as ordinaty chisels, on one. Turning gouges are ground with a much longer bevel than joiners' gouges. The ends also differ, for while the joiners' gouge is flat at the end, the wood-turner's gouge is rounded so as to prevent the corners catching in the work, all the cutting being done with the top of the curve.

Razors are ground hollow along the side so that in setting the edge very little need be removed by the oilstone. Not being subject to rough usage, the blade is of a very acute angle. In setting on the oilstone, the thick part at back must rest on the stone as well as the thin edge, and be moved about so as to produce a series of loops instead of a to-and-fro motion as with a chisel. Other ways are to give long sweeps from end to end of the stone, or a series of short strokes across the stone, but in all cases both heel and edge must rest on the stone. A razor requires a stone of very fine texture, so as to give as smooth an edge as possible, yet in spite of all that can be done the edge of the best razor is, when examined under a microscope, like a saw.

Emery on Oil Stone. Where a good quality oilstone is not available, one of low quality can be much improved by adding a little finest Elutriated Flour of Emery (common emery powder will not do) used with ordinary oil. It has a marvellous cutting effect, and produces just the right edge for wood-working tools.



EXPLANATION OF DIAGRAMS.

In the above diagrams the three at the top show : 1—The position of the hands when setting plane iron on the oilstone. 2—How the plain iron is held to the grindstone when there is no rest for it. This is the best way when the stone is uneven, it also allows the tool to travel from side to side of the stone. 3—The centre one shows how a plane iron is held down to the stone by a stick grasped in the hands. The other end rests on a ledge or the edge of a trough which should be about level with the centre of the stone. This method is suitable for a stone turned by power, if by hand it will be found rather tiring to the one that turns the grindstone.

A Razor is shown in section, both the edge and the back resting on the stone, which thus acts as a guide to keep the edge at the correct angle, though as razors are not all the same thickness at the back, the angle will vary a little with the thickness of the back.

Hollow Ground Chisel is shown next to the razor. All chisels and other tools have this hollow face if ground on a circular stone, and the hollow varies with the size of the stone, being greatest with the smallest sized stones. This is not a disadvantage as it leaves less metal to be taken off with the oilstone The angle shown where the edge touches the stone is too small, but every time it is put to the stone the angle becomes greater, until it is so altered that it is necessary to re-grind it. In an ordinary size of grindstone this hollow is hardly perceptible, but it is there all the same.

Wood Turners' Flat Tools are ground and set on both sides. It will be noticed that two of them are ground round at the top corner. This is to prevent the point digging into the wood in turning soft wood, though a skilled worker can manage with the sharp corner left on.

Wood Turner's Gouge, shown in 3 diagrams, is ground to a curved shape and the work is done entirely with the top of the tool, while with the joiner's gouge the whole curved end is used for cutting and is therefore not rounded off but is really a curved chisel. Both of these are set in the hollow in the face of a special oilstone, and a touch given to the inside with a narrow stone or *slip*. It is bad practice to set gouges on the same stone used for flat chisels, &c.

Joiner's Chisels are shown in three diagrams. The mortice chisel is very obtuse (large angle) as it is used for heavy rough work, and is also very thick in the body. The paring chisel is for the very finest work, the ordinary joiner's tools being ground to an angle between the two. The diagram also shows the effect of trying to make the oilstone do the work that should be done by the grindstone.

Penknife is shown in section as usually shaped, large blades of pocket knives have a larger angle. In either case, in setting them, avoid giving a razor edge to them, as it is too weak for ordinary usage. They should be set to the angle B in the axe diagram.

Surgical Instruments. Operating knives and lancets have a razor edge, except those for cartilage, which are more obtuse.

Axe and Hatchet, when in the hands of a skilled worker, may be set to the edge of a chisel, but for domestic use should not be sharper angle than B, while with careless grinding the edge often gets as obtuse as at A. Common hatchets are left rather soft, so can be edged with a saw-file.

Scissors are difficult to grind and in most cases require to be done at the top edge only. If the edge is too far gone for this, then the side must be ground a little on a small stone, but as little as possible as the true grinding is done at the top edge. If not very carefully done they will cut themselves, one blade cutting into the other. If not at once seen to will require a lot of metal ground out to correct them again. This is caused by the rivet being too tight or too loose, or the flats inside the joint not being corrected when grinding.

New Blade in Penknife. To replace a penknife blade the rivet must be taken out. Unless the knife is very fragile, the following is the easiest way. Make a rivet cutter by breaking off most of the blade of an old table knife, leaving about two inches. Lay the knife on its back and insert the cutter between the blade and the scale just above the rivet. A smart blow with a hammer will cut through the rivet, do the same at the other side of the blade, which can then be easily removed and the broken rivet pushed out. A new rivet can be made from a nail which must be a tight fit in the handle, but an easy fit for the hole in the blade.

Stropping a Razor. However carefully ground and set an edge tool is, it has when seen with high power magnifier a saw-like edge. To further improve this, it is finished on a strap of some kind. The old form was two pieces of leather glued to a board, one side treated with a polishing paste, the other left smooth. The more modern form is a flexible strap, one end hooked to the wall, the other end held in the hand. With this form it is important to keep a good strain on the strap to prevent the razor sinking down the surface, so producing a *round edge*. The razor should be drawn back first, the whole length of the strap, then turned over on its back, and again

brought to the other end, repeating if required, and finishing with a couple of strokes on the smooth side of the strap. The palm of the hand sometimes takes the place of a strap, and is also used by joiners, &c., after setting tools.

Carving Knife and Steel. The old form of steel is really a long file, having scratches lengthwise instead of small teeth. The more modern form is 4, 6, or 8 sided, having a hollow along each side, the edges of these sides are the cutting edges. Two or three wipes of the knife on a stool will remove enough metal to leave a sharp cutting edge. A good substitute for such a steel is a three cornered saw file, with the teeth ground off on a grindstone. It is much quicker than the ordinary form of steel, and is easily ground again when required. A tool constructed on a similar principle is made for sharpening knives. Two squares of very hard steel are fixed so that they overlap at their lower edges, the other parts forming a V. When a knife blade is drawn between the plates, a portion is scraped off each side near the edge, leaving it very keen.

Wood Scraper. This tool is used to remove (by scraping) the small inequalities left in wood by the plane. It consists of a piece of sheet steel, often a bit of a saw blade, and is ground to bring the edges all straight and square. To set this tool, it is held firmly against the bench, and the edges rubbed very forcibly with a bit of hard steel—usually a small chisel. This has the effect of turning over the edges, so producing what is so carefully avoided in all other wood working tools, viz:—wire edge.

Small Metal Working Tools such as gravers, are set on the oil stone in the same manner as wood workers tools, but being a harder steel they require a free cutting stone and frequent setting.

Oilstone Slips can be had in many sizes and shapes, and in all qualities. They are so cheap that it is a mistake to economise by doing without them.

Guides for Tools. Many forms of these have been introduced, in most cases consisting of a holder for grasping the tool, and provided at its other end with a wheel or roller which touches the grindstone or oilstone while the edge of the tool also touches the stone further away. This method ensures the edge being ground to the correct angle, and having the edge square to the side, provided the stone is level on the face, but with an uneven stone they do not produce such good work as is done by the free hand. Tools for ivory and complex ornamental turning are sometimes required to be very exact in the angle to which they are ground. Some special holders are made for these, which allow the tool to be set with mathematical correctness by means of a scale and index, the tool being ground on a horizontal disc supplied with emery or other grinding powders.

Centre Bits are sharpened with a file, which for this purpose should be "*dead smooth.*" The sweep part gets just a touch on the *inner edge,* never touching the outer edge, except to remove the burr. The blade is filed on the *upper edge* only, and if necessary any burr or wire edge may then be removed from the other side. The blade edge may then receive a touch from a slip of oilstone to finish off. When the sweep has been filed away below the level of the cutting edge the tool becomes useless.

COPYRIGHT

METAL TUBE AND PIPE BENDING.

Hot and Cold.

By M. COLE.

* * * *

BENDING CYCLE TUBING.

The tubes used in Cycle work are of mild steel and seamless, so that they have the advantage over welded tubes, that there is no seam to form a weak place. When a tube is bent, it will be found on measuring that the rounded side is considerably longer than the hollow side often to the extent of half an inch to the foot. In a badly bent tube, this may be accounted for by the hollow side being kinked, while the rounded side is flattened, while one that has been skilfully bent retains its circular section after bending. Where has this extra length come from? Careful examination shows that one side of the tube has stretched a little, while the other (hollow) side has been compressed, a much greater force being required to compress than to expand metal. All forces act along the line of least resistance, so that if an attempt is made to bend a tube without providing some means of resisting the compression, it would first bend a little while retaining its round section, but in doing so the tube would become harder by the compression, and on bending a little further, the force required to stretch the metal being greater than that required to overcome the circular shape, the tube would be flattened. To prevent this it becomes necessary to strengthen the arch by supporting it from the inside. This is best done by filling it with some material that requires greater force to compress it than is required to stretch the tube. It must also be of such nature that it can be removed after the bending is completed. Common resin does very well for very thin tubes that are bent cold, or for brass tubing. Lead is suitable for larger tubes or those that can be heated high enough to melt it out again, but there is the disadvantage in using either of these that the heat softens the tube after the bending has hardened it. Also that it is often necessary to bend tubes that have been polished or burnished or plated. Silver plated tubing bends readily without injury to the plating, but nickel plated tubes are spoiled by the coat of nickel cracking off on account of its brittleness. Sand is the best all-round filling for hot or cold bending except the sizes too small for plugging and ramming the sand, though many consider lead the best for cycle tubing. For thin tubing glue offers enough resistance.

BENDING WITH SAND. If it is intended to bend the tube without heating it, it must be softened or annealed first. Mark with chalk the parts that are to be bent, and heat to a bright red, cover with hot ashes and allow to cool as slowly as possible. The slower the cooling the softer the tube will be made, bending it cold hardens it again to some extent. The heating is best done by placing the part to be heated in a cast or wrought iron gas pipe in which it is an easy fit. This does a great deal towards keeping it clean and free from scale. For hot bending this annealing process is not required.

Plug the Ends of the tube. One plug is of course inserted before the sand is filled in, the other one after ramming the sand. The plugs require some care in making, as they must be a good fit, yet possible to remove. They should be of hard wood turned in the lathe, a gentle taper so that at least one inch will enter the tube before any force has to be used, and should be long enough to give a good hold for the hand in pulling it out again. The less taper the plug has the longer the bearing will be when forced into the tube, as the whole resistance depends on the friction between the surface of the plug and the part of the inside of the tube it touches. Some workers prefer a soft wood plug of less taper than the hard ones, as soft wood compresses enough to enter and then expands again and grips well on the side of the tube. When inserting the second plug care must be used that it not only touches the sand, but presses on it with considerable force.

Ram the Sand into the tube for the purpose of supporting it from the inside. Unless it is very tight it gives no support, and if unevenly packed the soft places compress and allow the tube to kink or flatten there. The sand must be quite dry, otherwise steam will form when it is heated and the plugged tube would be like a steam boiler with no outlet, and either burst or shoot out the plug. Use fine *Calais* sand that has been thoroughly dried in an oven, and is free from lumps or dirt. Place a little sand in the tube and ram well down with a rammer that really fits the tube. The head may be of box-wood or brass, the handle of any suitable material, but it must have a flat face—a rounded face never packs the sand properly. Ramming with any stick that happens to be handy is a mistake. It is easy to turn a set of brass or wood heads to fit the tubes generally used. If the head does not fit the tube the sand will not pack properly.

Cold Bending is the method used in the large cycle factories, and is a far better method than the hot way as no scale is formed on the tube, but the cold process requires more appliances than are usually found in a repairer's workshop. The method will be readily understood on referring to the diagrams. The tube is cramped as shown in one of the tools, and merely pulled into shape on the curved block as shown. When a good length of tube is used the tube itself gives enough leverage. If short, another tube must be passed over it, but should fit well to prevent marking the tube to be bent.

Hot Bending requires fewer tools but more skill than cold bending, and has the disadvantage that it weakens the tube, but in most

workshops there is no other way. When bending a tube it must be at a bright red, and any attempt to bend it when it is below that heat will spoil it. It is far better to make two heats to a bend than to run any risk. In fact a sharp bend usually requires two heats. Chalk marks must be put on the tube to show the locality of the bend, so as to get the greatest heat there, as *the tube bends easiest at the hottest part.* This may be utilized to bend tubes without curved blocks by merely grasping the end in the vice, and while at a dull red heat apply the blow-pipe flame to get a bending heat just where wanted. The tube can then be bent by pulling the free end. With a little practice it will be found easy to graduate the heat so as to get the bend at the right place.

Remove the Sand from the tube when bent. This is sometimes a little difficult as a rod cannot be pushed down, though easy enough with a straight tube, as the sand is nearly a solid mass. A tool like a chisel at the end of a flexible cane is the best for this purpose, as it allows the tool to be twisted and at the same time follows the curve. Twist so as to loosen some of the sand, removing the tool as often as required to eject the loosened sand.

TOOL AND BLOCKS FOR TUBE BENDING. There are two classes of blocks used for bending tubes. In the simpler form the tube is pulled against a curved block having a groove in it, which need not be part of a circle. The other sort where the pressure is put on by wheels, so that the part they travel over must be a segment of a circle. Both sorts are shewn in the diagrams. The first form is very easy to construct and may be of wood. If used for hot tubes the hollow may be lined with asbestos sheet, or sheet brass or half a tube, but a block may be used several times with hot tubes, as the charred part protects the remainder of the block, and oak especially will stand a good deal of surface burning without much injury or alteration of shape. *Further particulars of bending over blocks is given in the explanation of the diagrams.*

BENDING BRASS AND COPPER TUBES. The blocks described for bending cycle tubes will do for brass or copper tubing, but all small sizes bend well over wood blocks. They should always be bent a little further than required, as they go back a little when the pressure is removed. Brass tube must be annealed before attempting to bend it, or it will be much more difficult to do. Make the tube red hot at the part to be bent, and quench in cold water, being careful that the upper end does not point to the face, as the heat of the tube causes some steam to form in it, which rushes out at the other end and may cause serious scalding. Do not attempt to bend brass while it is hot, as it is then very brittle. $\frac{3}{8}$ in. and $\frac{1}{2}$ in. brass gas tube are easily bend by hand over the shaped block if long enough to form a lever to bend it by, if not some other tube must be slipped over it to form a handle. Smaller tubes than $\frac{3}{8}$ in. can usually be bent to shape by the fingers without any blocks. Larger sizes than $\frac{1}{2}$ in. as a rule can be bent to a curve of quarter circle of 12 in. radius without filling, but for smaller curves must be filled with lead for pipe over 1 in., or resin for the smaller sizes. There is

a seam in gas brass tube where it is joined, having been made from a strip of sheet metal. It is easily seen and should be kept either on the inner curve or at the side of the bend, but never on the outside. Stout copper tube must be filled with melted lead unless the bend is a very slight one. The lead is not so easy to remove as resin. Some thick copper pipes cannot be bent without ribs forming on the inner side of the bend, these will have to be hammered out with a small faced hammer. Brass tube kept in stock a long time exposed to the fumes of gas or acids becomes rotten, and this is sometimes the reason for not being able to get bends. To prevent the tube being injured when gripped in the vice for bending, cheeks must be used to protect it. These are best made by cutting a groove in wood slightly less than half the section of the tube, so that when gripped between a pair of these the wood will be compressed enough to bring the whole surface of the tube in close contact with the wood. As polished tubing would be spoiled if gripped by ordinary tools to screw up or unscrew, a leather tube wrench should be made. This is merely a strip of suitable size long enough to go say six times round the tube. It is screwed to a wood handle about 18 ins. long, having near the jointed end a groove cut across it the same curve as the tube. The strap is lapped round the tube in a spiral, and the friction between the leather and the metal is usually enough to carry the pipe round.

Brass Cased Tube having only a thin layer of brass on an iron body, cannot be bent, so that bends for use in connection with it must be of brass.

Zinc Tubes are used for bell wires, and are built into the walls of houses. Though seldom required to be bent, they can be done if heated to a moderate degree.

Wrought Iron Gas and Steam Tube is bent red hot. As a rule it is grasped in a vice as near as possible to the hot part, and pulled to something like the shape required. The horn of an anvil is sometimes used to guide the shape, but more frequently it is just a case of heating a little and bending a little until it is near enough, great accuracy not being required. The parts beyond where the bend is are to be cooled by pouring water over them so as to localise the heat. Any slight flattening is disregarded, but the strength of the pipe keeps it at nearly circular section.

Thin Brass Tubing made for telescopes, &c., cannot be bent if over $\frac{3}{8}$ in. bore, and then only if filled with resin. The smaller sizes of similar tubing can be bent with the fingers without filling if previously softened.

Aluminium bends well when cold, if annealed first. The treatment is the same as for brass. When heated it is brittle. To soften heat to redness in a muffle or oven, so as to be kept from the air while hot, quench in cold water kept cold by running supply.

Cast Brass Tubing made in various shapes for gas and water fittings cannot be bent, as it is very brittle and breaks easily.

Bending with Water. Water being practically imcompressible is sometimes used for bending pipes. Both ends are closed, one or

both being provided with taps. If the tube is quite full of water and the taps closed, any flattening of the tube would give less space for the water, and as it will not occupy less space the flattening is resisted or else there is a bulge at some other part of the tube, this being the drawback to the process when used for lead pipes of light weight.

Sheet Iron stove piping or tinplate pipes, if of light material, can be shaped by a process, which though not really bending produces the same effect. It is done in a machine used by tinplate workers for beading. The pipe is placed so that one of the wheels enters it as far as required, the other being at the same place but outside the pipe. The inner wheel has a ridge, the outer wheel a hollow on the face, and the metal between them is forced to assume the shape of a ridge or bead, which is deep or shallow according to the number of times it has been rolled to and fro between the wheels. If the ridge is the same depth all round, the pipe remains straight, but if one side is deeper than the other or the bead on one side is narrowed and the other side left wide, the amount of the difference between the sides shapes the tube to a curve to that extent. Usually several beads are made and a bend at right angles is readily obtained by this process, and is known as a **lobster back.**

BENDING LEAD PIPES. Lead Pipe differs from pipes of other metals from the fact that the lead flows under pressure as if it were a paste instead of a metal, making it easy to dress some of the metal from one side of the pipe to other, so that one part becomes double the thickness of the pipe at the opposite side without altering the bore from its circular section. This renders bending very easy. Lead has, however, the disadvantage of stretching so readily that unless great care is used the side most strained becomes proportionately thinner until too weak for its purpose.

Heavy lead water pipes used for high pressure supply bend without any preparation, and go very little out of shape if reasonable care is used. Light weight pipe used for gas supply and for overflow, waste, and similar water fittings where there is no pressure, is generally the sort that requires bending. Such pipe must be filled before bending or it flattens at the inner side of the curve. Sand does very well for the purpose aud need not be dried. The ends are plugged with a bit of soft wood. Water is even better for filling provided the pipe is quite full. If any space is left at top, the tube will flatten to that extent. The quickest way is to solder a tap at each end of the pipe. When filled either by sand or water, the pipe can be bent over a wood block, doing a little at the time, and between the bends dressing some of the metal from the inner to the outer side of the curve with a wooden mallet or dresser. In most cases a slight flattening or creasing at the bend is of no consequence, but if required to be very exact it must be trued up by sending one or more boxwood balls through the tube. They should be $\frac{1}{16}$in. less diameter than the bore of the tube. There are several ways of doing this: 1—Two boxwood balls are placed in the pipes, one each side of the bend. A brass ball not quite so large and provided with a loop to which a strong cord is tied is used to force the wood balls forward

by being dropped on to them alternately until they meet in the bend, the blows are then given to one only, until it is forced past the bend and the two can then roll out This can be done only in small sweep bends, larger curves are done with several balls, the shock from the brass ball or a hammer being transmitted from one to the other. 1—A boxwood ball having a hole through it is threaded with a thin rope, and the rope passed through the pipe is taken round a roller provided with lever at its ends, and capable of turning in bearings forming a windlass. The pipe is fastened to the bench, and winding up the rope pulls the ball through the pipe and opens out any flattening. When the inside of the bend is easy to get at, it can be dressed to shape with a dummy, which is merely a lump of lead at the end of an iron rod forming a handle which may be straight or curved as required. The easiest method of all for either lead or brass pipes is with the Spring Mandrel or Shaper. This is a spiral spring of steel wire that fits well in the pipe and bends with it. To insert or withdraw it the end is twisted, which slightly reduces the diameter of the tool. This does well for all bends of moderate sweep. The seamless lead pipe S bends used for w.c. and lavatory traps are made in a special machine, which forms the bend at the time the pipe is being made. Similar work done by hand is usually done with pipe split lengthwise in two parts, and soldered together again after they are shaped.

BENDING GLASS TUBES. Though glass is not one of the metals, it is so much like one that the method of bending glass tubes may with advantage be given here. A common gas burner having a flat flame will do for small size tubes, though a Bunsen or Atmospheric burner is far better as it prevents soot forming on the tube, and some sorts of glass become permanently blackened from it. A blow-pipe is not necessary for bending tubes. Thin tubes are difficult to bend without kinking, but those of ordinary strength are easy enough. The part to be bent is heated in the middle of the flame, (if flat flame burner hold the tube along its length). For greater steadiness the elbows may rest on the table, the burner being fixed about six inches above it. The tube is grasped in both hands, one each side of the intended bend. Keep the tube rotating in the flame so that it is evenly heated. When it is felt that the tube has softened, which is before the change of color occurs, remove from the flame and bend, at the same time bringing the hands together slightly as if to shorten the tube. This is the main point to be attended to, and most failures may be traced to pulling the tube a little longer while bending it, which causes the flattening. If it is desired to produce a large bend, a portion of the bend may be made at each heating, using as many heats as required. If a large enough flame can be had, any size bend can be made at one heat. If the bend is near the end of the tube, a stick can be inserted in the end and used as a handle. The sharp edges of a cut tube can be rounded by holding them in a gas flame until a slight change of color shows the glass is soft enough, it must be at once removed and the edge will be found rounded. If left hot too long, the opening contracts and the hole gradually closes. After the job is finished, leave it in

a warm place to cool gradually, or at any rate avoid draft of cold air getting to it.

Celluloid Tube is bent by softening it in hot water. To prevent flattening it is filled by inserting a piece of rope, which if smooth leaves the tube level, but if like cable it allows the celluloid to sink into the hollows and so form a pattern on it. The rope is removed easily after it has set.

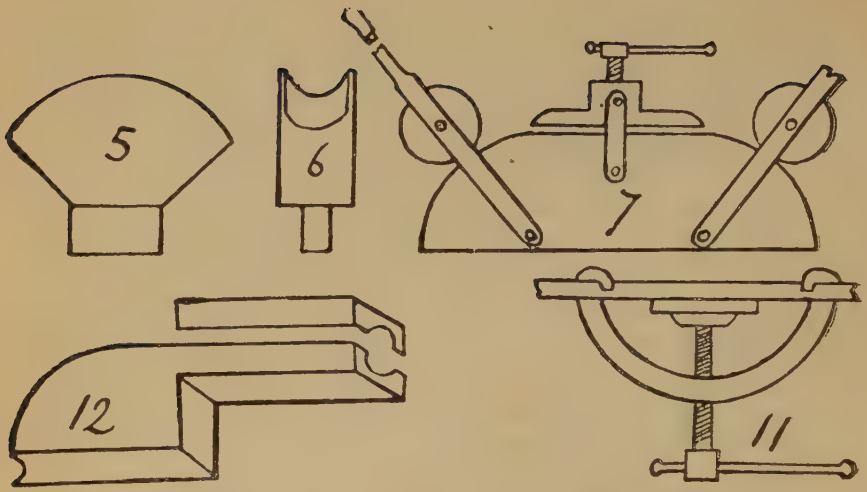
Removing Dents from Trumpets, Spirit Flasks, &c. Removing accidental bends is so closely allied with bending tubes, that some methods of doing this are here given. Brass musical instruments are necessarily made from the thinnest brass tubing except the bell, which is made from sheet metal. The tubing is filled with resin before bending, and bent over blocks as described for brass gas tube. Being of very good quality brass containing plenty of copper it bends well, but on account of its thinness is very liable to injury by accidental blows. While making new instruments is in the hands of a small number of firms, removing dents is a job frequently requiring to be done. The following instructions show the easiest way of doing the work :--

Solder a small loop of wire to the dented place so that it is attached to the lowest part of the hollow, and fasten a strong string to it, the other end being tied to some fixed object. A few jerks carefully graduated will usually bring the surface up to its correct form again. The loop can be removed by melting the solder with a blow-pipe flame. This is the method used in removing the dents from Hydrometers or other instruments having hollow chambers of thin metal.

If the dent in a brass tube is so situated that it can be got at from the open end of the tube, it can be done with a piece of hard wood turned to required size and having a flat on one side. This is fixed in a handle of required length. Insert so that the flat comes just under the dent, then turn slowly and so force the metal to right shape.

Forcing a boxwood ball through the tube and past the dent is another way. If the tube is open at both ends, the ball can be easily pushed through, or may be pierced and a strong string threaded through so that it can be pulled past the dent, which is preferable to pushing it. If the tube is curved, several balls can be used, a blow on the outermost will be transmitted to the front one, which should be slightly larger than the others as it has to remove the dent, while the others only transmit the shock. A special tool is also used for straight tubes consisting of an expanding mandrel attached to a long handle. The mandrel when in position can be expanded by twisting the handle to the full size of the tube.

Another way is with a **Snarling Tool**. This is a sort of hammer with small head and long steel handle, which must be somewhat flexible or springy. The other end of handle is bent so that it can be gripped in a vice. The tube is placed so that the handle enters it as far as required, the head of hammer resting just under the dent. If the handle is struck near the vice, the rebound causes the head to strike a blow on the dent. A series of carefully graduated blows will remove the dent. This method is very suitable for metal flasks, vases, &c.



EXPLANATION OF DIAGRAMS.

Fig. 12.—Bending blocks for brass and other tubing. This shape is the most useful and is very easy to make. It is made of any hard wood, or for an odd job may be of soft wood if for cold bending. The half-round groove should be slightly smaller than the pipe to be bent, so that when gripped in the vice by the two flat parts the pipe is firmly held. It is then bent by being pulled against the rounded end. A set of these should be made for the various sizes of tubing likely to be bent. When used for hot work, the grooves may be lined with thin asbestos sheet or with sheet brass. Another way of using these blocks is to screw them down at such distance apart that the pipe to be bent will just fit between the straight parts, so avoiding the use of the vice.

Figs. 5 and 6 are side and end views of bending blocks to be held in the vice. One end of the tube is fastened to the bench or some other suitable support, and the other is pulled over the bend, using an extra length of pipe as a lever.

Fig. 7.—Bending machines for handle bars. The middle of the tube is held in the screw-cramp at the top. This on being pulled down by the handles pulls the tube into shape, the roller preventing rubbing friction.

Fig. 11.—Screw cramp for straightening heavy tubing, if to be only slightly bent, or with shaped blocks it can be used for any curves.

See also the following Sections :

"Cycle Brazing" for full instructions on all brazing jobs.

"Wiped Joints for Lead Pipes" for lead work.

"Metal Screwing" for all screwing with stocks and dies.

COPYRIGHT.

Tempering Steel,
Annealing and Case Hardening Iron.

By M. COLE.

* * * * * *

Pure Iron is a soft, bright metal, not liable to rust, but is only known as a scientific curiosity. Iron in ordinary use is of the following varieties:—

1—**Best Charcoal Iron,** which is the best in ordinary use, is smelted with charcoal instead of coal, thus avoiding one of the main causes of impurity—the sulphur, &c., contained in the coal.

2—**Ordinary Bar and Sheet Iron,** produced by the ordinary process. This is pure enough for all mechanical purposes, and can be worked hot, forged and welded. It is converted from cast iron by puddling, a process by which the carbon is burned out of it.

3—**Cast Iron,** a mixture of iron and carbon, the carbon being added to enable the iron to be melted so as to be poured into moulds. The quality varies with the nature and quantity of impurities present.

4—**Malleable Cast Iron.** This is a good quality of cast iron that has been kept at a heat but little below fusing point, until the carbon is burned out of it, and the iron is almost pure.

5—**Steel,** a mixture of **Iron and Carbon,** with other minerals present in small quantities. Steel differs from cast iron in having a smaller proportion of carbon, and in having the peculiar property of **Tempering.** The proportion of carbon in steel varies from ¾ per cent in steel suitable for **Dies, &c.,** to 1½ per cent in **Razor Temper** Steel, while in cast iron it varies from 2½ per cent upwards. Iron in any of its forms is hardened by being heated to redness, and rapidly cooled. Castings intended to have a very hard face are cast in iron moulds, which chill the castings quickly—others intended to be turned or bored, &c., are cooled as slowly as possible, and are from iron free as far as possible from impurities. Steel is, before being turned, bored or otherwise cold worked, heated to redness, and cooled very slowly which **anneals** or softens it. If the finished tool is required to be very hard, it is again heated and cooled quickly in water or oil, but if required to be tough as well as hard some of the hardness must be removed by **tempering.**

Case Hardening is a method of converting the surface of iron to steel. The case hardened part can be tempered. Steel can also be case hardened, so that one part of a tool can have a higher percentage of carbon, than the remainder, so combining hardness near the surface, with toughness in the body of the tool. Until a comparatively recent date, many tools were made from wrought iron, case hardened, on account of the high price of steel.

Tempering Steel. Tempering is a process of softening, *not* as is generally supposed of hardening steel. Before steel can be tempered, it must be hardened, then a portion of the hardness removed. Tempering is a process peculiar to steel, and other forms of iron

cannot be tempered. This is the feature distinguishing steel from iron, some forms of cast iron having very little more carbon than some of the steels. Other forms of steel, as some of the *mild steels*, will scarcely temper at all, being nearer to iron than steel in their composition. Other brands of steel, as Tungsten steel, do not temper nor can they be either hardened or annealed, but are rolled hot to suitable section, and ground to required cutting edge. They are used in small pieces fixed in a tool holder. This class of steel can usually be detected by the difference of the sparks given off when grinding on emery wheel. For some reason that has never been explained, when a piece of steel is heated to redness and quickly cooled it is hardened, so much so that it will break like glass if dropped on a stone, but if the same piece of steel is then re-heated to a lower heat than before and cooled, it is no longer so brittle, but more or less springy, being then tempered. If it were not for its brittleness, a drill that is dead hard would be an ideal one for cutting, as it would keep its edge. As it is we are compelled to use a tempered drill, which, though less hard, is tough enough to stand working. Steel changes color with the degree of heat to which it is subjected, but it should be remembered that while the degree of temper denoted by a certain color is always the same for the same quality of steel (provided it has previously been equally hardened) the same color would show various degrees of temper for different qualities of steel. Again color does not prove steel to be tempered. If a piece of soft steel be heated to straw color and quenched, it will not have the same temper as if it had previously been hardened. The color is caused by a thin film of oxide. The proportion of carbon in steel varies so much, that the efficiency of a tool depends greatly on whether the steel it is made from is suitable for the purpose. What is suitable for a razor will not do for an axe. If the proper steel is not used, the result is never satisfactory, and the workman who tempered the tool is blamed, while the fault lay with the one who selected the steel. Another cause of unsatifactory tools is when the tool is overheated or *burned* in working. Steel tools, whether knives or turning tools, &c., must be well hammered while at the right heat, gradually using less force as the metal cools. Tempering, however carefully done will not replace the hammer work required to make a good tool. The tool should not be heated above a blood red, and the fire kept clear of sulphur fumes. Charcoal is the best fuel for heating tools for tempering, good quality coke is the next best. Gas flame, though very useful for small tools, contains a good deal of sulphur. Where possible, a length of iron pipe should be used in the fire to keep the steel clean. Frequent reheating of steel spoils it just as overheating does, in both cases some of the carbon is burned out of it. When this happens the end should be cut off and another forged on it. Cracks (apparently insignificant) and sharp bends cause tools to split in tempering.

Process of Tempering. Heat the tool to a blood red when looked at in a dark corner, then dip in cold water holding the tool perfectly straight, point downwards, keep there till cold, it will then be quite hard and brittle; now clean up one of the surfaces with a flat stone, and re-heat till it shows the desired color, at once dip in water and hold there till cold, keeping the tool perfectly straight; it is then

ready for grinding. It is as well to rub the surface that is to show the color with a piece of stone while hot to clean it.

Hardening and Tempering at one operation. Grind a smooth place on the body of the tool and another on the head, heat to red and then dip the head till the body shows light blue color, lift out of the water and hold till the heat of the body spreads to the head and shows the right color, say light straw, then quench the whole tool. Once in the water a tool must not be lifted out till cold. The steel is white when dead hard and cold. A good process of tempering much used in U.S.A.: Heat the tool in a clear fire and while hot rub on some common yellow soap, then heat to cherry red, and quench off in some petroleum. Keep away from the fumes. Everyone thinks his own method of tempering the best. Below are opinions of practical men on the best way to do it, they are all useful though contradictory.

"Boil the water before using."
"Spray the water on the drill."
"Use water heated to 100° F."
"Put a little oil on the surface."
"Put plenty of salt in the water."
"Use pure clean water quite cold."
"Keep the drill perfectly still in the water."
"Move the drill gradually lower in the water till cold."
"Dip the head and hold 10 secs. before dipping the remainder."

Tempering Taps and Dies. The taps, dies, and plates having been made require hardening and tempering. First fill the threads with hard soap to avoid scale and keep them clean ; heat a large block of iron in fire to nearly white heat, remove and place the tools on it, when they reach cherry-red lift off, and keeping taps in an upright position, plunge in water—if slanting they will twist. Dies must be dipped flat. When cooled, clean up a surface with emery or fine stone, (pumice does well) place again on hot block till the head of tap shows light blue, dip the head only in water, quickly remove and re-place tap on hot block, allow to heat till the cutting part is a LIGHT CHESTNUT BROWN, then quench in water. Dies are treated the same way as taps. Dark straw color gives a good temper with some grades of steel. It is convenient to hold the head of taps in tongs while re-heating. A tap bent in tempering can be straightened by heating and careful pressure with hard wood—should not be heated high enough to show any color.

Dipping the Tool for hardening and tempering is by no means an easy operation. If rod-shaped, and to be of equal temper throughout the length, it must be dipped vertically, lowering it slowly in the water intil the whole is immersed. Where the end only is to be used as in drills or turning tools, only a small part is immersed, the remainder being out of the water cools slower and is softer and tougher, so less liable to break. With tools or articles of irregular shape, it is sometimes as well to shape a bit of iron, and wire it on to the thin or slender part, to prevent it cooling sooner than the heavier parts, and so cause warping. Another and perhaps better way is to wire the tool on a block of iron, so as to give greater mass to it, and so cause it to heat and cool more regularly than it would

have done alone. Using the bath of melted lead or oil of course renders this unnecessary.

Circular Cutters having holes through them (as is usually the case) are difficult to heat and cool regularly. The hole is by some workers plugged with iron, or with a mixture of clay and iron filings or scale. If the hole does not go all the way through, the cutter must be dipped with the hole upwards, otherwise the steam formed in the hole will prevent the water entering it, and probably cause the cutter to split. A spray of water is better than dipping for tools having a large surface, but the tool must be moved about so that the water touches every part of it. This method has the advantage that all the water touching the tool is cold, whereas, in dipping a film of steam or of hot water is in contact with the metal, in fact steel can be softened by heating to full red and dipping in boiling water if not moved about, and left in position until the water gets quite cold ; it can be suspended by a wire. Cutters of small bulk, and having a hole large in proportion to their size, can be heated for hardening or tempering, by inserting in the hole a rod of iron of white heat. In a similar manner, a large block of hot iron, having a central hole may be used to heat small tools, which need not touch the iron, and are so less liable to scale.

Tempering soft back Hack Saws. These last longer and are less liable to break if the edge only is tempered, the remainder of the blade being left. Heat the blade to cherry-red, then dip the edge only in cold (raw linseed) oil, holding it until the whole blade has cooled, then clean the surface and re-heat till dark blue colour, and dip the whole blade in the oil, edge downwards. All small tools are best heated for tempering by being placed on a piece of iron heated red or white hot. Very small tools can be treated by being placed on a piece of sheet iron that is heated from below by a gas jet. If the heat is at one corner of the sheet iron, the tools can be moved from the hottest corner to a cooler place with a bit of wire. One cause of tools not being able to keep a good cutting edge is that they are frequently forged too near the finished shape and size, a great mistake. The golden rule is "**Forge thick—grind thin.** After forging steel, no matter how well it is done, the metal for a distance (more or less) below the surface is deprived of part of its carbon. There is no way of avoiding this, the remedy is to leave the tool so that there is enough to grind off to get rid of the surface metal.

Dead Hard Steel is sometimes required as for cutting glass, if a suitable steel is used, mercury (quicksilver) should be used for dipping.

Tempering Springs. This is best done by a method known as "*blazing off*," which gives a very tough result. Heat the spring to red, quench in cold water to harden. Now dip in raw linseed oil, and hold in the fire till it blazes up, allow to burn till the oil is burned off, and quench in cold oil. Another method is to heat the spring, quench in cold oil bath, and temper in a bath of proper heat. Mercurial Thermometers can be had graduated to over 600° F., the heat at which oil boils, this gives steel a pale blue temper, low enough for any article, and used for spectacle frames, &c. If required lower temper than this, melted lead may be used, a bath of which is con-

venient for heating tools for hardening. The tool can be dipped and withdrawn until the right color is obtained. The lead bath is used for softening the tangs of files without drawing the temper of the body, which is left hard and brittle.

Tempering Small Springs. Heat the spring slowly and carefully (to avoid unequal expansion) to a low red, quench them in luke-warm water. Place the springs in an iron ladle with enough tallow to cover them. Heat till the tallow melts, adding more if required so that they are well covered, continue the heat until the tallow blazes up in a large flame, then set aside to cool. Some workers use a mixture of tallow and resin.

Temper and Tempering. The word **Temper** is also used to denote the proportion of carbon contained in steel, or quality of steel, for instance: steel sold as "**Razor Temper**" means steel suitable for razors, *not* steel that is already tempered.

Tempering Brass. This cannot be done in the same sense as steel is tempered, but brass, copper, and many other metals can be hardened by hammering. Brass springs are used for many purposes and they are made of a suitable brass, rolled or hammered till springy. Most forms of brass will bear this hammering, but bronze (tin and copper only) is most suitable for this purpose. It can be softened again by heating red hot and quenching in water; the reverse of the treatment of steel.

Heat the Steel to the lowest heat it works well at. Hammer as much as possible while hot, but not much after the color has gone. In hammering, give many light blows rather than a few heavy ones. Colors mentioned are those seen in the dark. Colors vary to the eyes of various people. Light red to one is dark red to another. Do not harden the tool by the same heat used to forge it; allow to cool and re-heat. If your steel is too low in carbon for the tool, case-harden it. To prevent the edges of tools being burned in heating, rub with a mixture of soap and lamp-black.

Straightening Hardened Steel. Files are not tempered after hardening. They are heated in melted lead and quenched in salt and water. Before the interior of the tool has time to chill they are removed, and if bent are straightened between iron bars, and at once dipped again till cold. Any tempered tools can be bent or straightened in this manner if heated, but not so much as to show color. Tools tempered blue need only be warmed.

Tempering Steel Pens. These, and other small articles of steel, are tempered in large numbers at the same time. Put in an iron pan and heat till full red, stirring them about so that they heat equally to a good red. Empty at once into tank of cold oil, then lift on to wire netting and allow to drain; wash well with soda and water till all oil is removed, and dry—then place in drums of wire netting revolving over gas flames (Bunsen) until the right color—remove at once and allow to cool in air. They can be done on a metal plate instead, if there are means of heating it.

Blueing Clock Hands and Spectacle Frames. Use a piece of sheet iron forming a small table, with a powerful gas burner under corner. Spread the work on the plate so that it gradually heats, then push one at the time to the hot part, but as soon as it shows

the color required, remove it to the cooler part, or push on to a cool plate. Some clock hands are blued with a colored varnish.

Drop Forgings. Some scissors and other tools are now made in dies, the hot metal being inserted between a pair of them, and pressed to the shape. These are tempered just as other goods are, but the absence of hammering during the process prevents good tools being made by this method, even when good steel is used.

Hard or Soft Temper? A tool tempered hard and of high carbon steel breaks at the edge much sooner than one tempered low or of low steel, but it does much more work in the same time, and is a saving of time in the end. Don't make chisels too long, they are more liable to "broom up" than shorter ones. When the chisel head "brooms up" do not attempt to forge it again, but cut off or grind off—in any case get rid of the spoiled part before it causes an accident. For a similar reason the top end of a chisel must be left soft. The hammering will in any case make it brittle, and fragments are liable to fly off. When grinding the edge give a little attention to the other end.

ANNEALING.

Glass and most metals are hardened by being cooled suddenly from a high temperature, but are softened by slow cooling. As a general rule, the slower the cooling, the softer the result. All articles of glass are annealed by being placed in an oven and raised to a high temperature. The oven is then slowly cooled, usually for several days. Wire is hardened during the process of drawing, and as the smaller sizes are drawn through a good many holes, it is necessary to anneal the wire during the operation several times before completion. Even gold, the most malleable of all the metals, must be annealed during the process of coining or of wire drawing.

Copper, like most other metals, is annealed by heating to redness and allowing it to cool slowly. If quenched in cold water while red hot, it becomes brittle, but if dipped for a moment and then allowed to cool, it becomes hard.

Brass is softened by being heated to redness and quenching in water. As brass and other tubes have frequently to be quenched in this manner, it is as well to point out that if the end of a tube is heated and put in water, steam forms in that part of the tube and rushes out at the other end, so that *unless the end is held away from the face or body, serious scalding may take place.* The heat from the hot end also travels in the steam or hot air, and makes the upper end unpleasantly hot.

Iron and Steel, to soften, must be heated to a greater heat than when last worked, and allowed to cool as slowly as possible. The slower the cooling the softer the result. For small tools or other articles, a good method is to use two fire clay bricks, both made red hot. Heat the steel to redness, place between the bricks and cover all over with hot ashes. Leave until quite cold throughout, which will probably be 24 hours or more. Another good method for small articles is to pack them in a sheet-iron box with charcoal, lime, or whiting powder. Close the box air-tight, and heat until red hot all through. Then cover the whole with hot ashes to a good depth.

Cast Iron. For small articles, place in a charcoal fire until heated to a dull red heat, then cover them over with powdered charcoal or sand, and allow to remain till cool. Larger castings require a special furnace and take several days, or even two or three weeks to anneal, but if of good quality they are then so soft that they can often replace copper so far as malleability is concerned.

CASE HARDENING.

This process, largely used when steel was much dearer than now, gives a thin coating of steel to wrought iron, or to describe more correctly, converts the surface of iron into steel for a short depth below which the iron is not affected. The depth to which the carbon penetrates depends upon the length of time to which it has been heated with those substances that give up their carbon to the steel. Charcoal gives the best results, burned leather or bones ground to powder and charred are also good. Quick effects are got by a chemical treatment, but the results are not so good. With the carbon process it is very important that no air be allowed to get to the work during the process of heating. This is usually done in iron boxes of some kind. Very small work can be done in tubes of gas or steam pipe, the ends either plugged or closed with screwed caps. Larger work is put into boxes of cast or sheet iron, the lid fastened down with wire or by other means, and luted with clay so as to prevent any air entering. The articles to be hardened are packed in the box in such manner that they do not touch the sides of the box or each other. There should be at least one inch thickness of the carbon or bone surrounding the articles. A small vent must however, be left in the clay luting, to allow the gas generated from the charcoal or bones to escape. If bones or leather cuttings be used, they should be charred or partly burned first. If nuts or screws, or any similar work, is to be hardened, some of the powder should be worked into the threads so as to ensure contact with all the surface. It is important that the box should be uniformly heated all over its surface, raised to an orange color heat, and kept at that heat 14 to 24 hours. The box should be opened as soon as it is removed from the fire, and the contents at once dropped into cold water. If the work touches the water before any air can get in contact with it, the result will be a bright surface. If the air gets to them, they will be dark or black. If a good color of surface is required, it is important that no oil should be on the work. A thinner coating of case hardening can be produced by heating for a shorter time, say three or four hours. To get the mottled effect on case-hardened work, quench in urine.

Case Hardening Small Screws. Mix with hot water two ozs. of Prussiate of Potash, and four ozs. Common Salt using very little water so as to make a thin paste, add powdered charcoal to make a thick paste. Put a good layer of this at bottom and sides of a sheet iron box or old saucepan. Put in the screws so that they do not touch, then put on a good layer of the paste and press well down so that the paste is well in contact with every part of each screw. Raise to a red heat, and keep so for five minutes or more; then put box and contents in cold water.

TABLE A.—Compiled 100 years ago and still unsurpasssd.

430° F.—	Faint Yellow	Lancets
450 ,,	Pale Yellow	Razors
470 ,,	Full Yellow	Penknives
490 ,,	Brown	Scissors, Cold Chisels
510 ,,	Brown, with Purple Spots	Axes and Planes
530 ,,	Purple	Shears and Table Knives
550 ,,	Light Blue	Swords and Watch-springs
560 ,,	Full Blue	Small Saws
600 ,,	Dark Blue	Hand Saws

TABLE B.—Colors of Finest Tool Steel at various heats.

430° F.—	Very Pale Yellow	Gravers, Drills, Light Turning Tools
455 ,,	Straw Yellow	Paper Cutters, Milling Cutters
495 ,,	Brownish Yellow	Taps, Punches, Reamers, Twist-drills
528 ,,	Light Purple	Plane Irons, Wood Tools
535 ,,	Dark Purple	Wood Chisels
570 ,,	Clear Blue	Screw-drivers, Springs
600 ,,	Dark Blue	Saws for wood
610 ,,	Pale Blue	,, ,,

Tools of awkward shape should be heated in Linseed Oil, which boils at 600° F.. so that the tools cannot be overheated.

QUALITY OF STEEL FOR TOOLS, &c.

TEMPER.	CARBON %	PURPOSE SUITABLE FOR, ETC.
Razor	1½	Difficult to work, easily burned by overheating, makes best metal-turning tools if well made.
Saw-file	1⅜	Requires careful working, not to be heated over cherry red.
Tool	1¼	Usual for tools—difficult to weld.
Spindle	1⅛	For Milling Cutters, Taps, Dies, Mill Picks, can be welded. (This is NOT the steel used for Wool or Cotton Spindles).
Chisel	1	Best all round steel where only one sort is stocked. Best for cold chisels—welds easily.
Sett	⅞	Best for setts, stands hammering well. Welds very easily.
Die	¾	For large tools, stands heavy blows well. Welds very easily.

COPYRIGHT

Metal Screwing.

How to Make and Use Stocks & Dies, Screw-Plates & Taps.

By M. COLE.

* * * * *

Metal Screws, when made without a lathe, are cut with SCREW-PLATES, or DIES held in DIE-STOCKS for male or outside screws, and with taps for inside or female screws.

Watch Screw Plates. Screw Plates are of two sorts, those for very small screws as in watch work are merely a screw-thread in a steel plate, the thread of the screw is formed by the metal being forced into a ridge, this is the worst method and is only used for very small work.

Larger Plates. The screw plates used for larger purposes have two small holes drilled next to the screwed holes, cutting away about an eighth of the diameter each side, sometimes the holes are only slit each side instead of the small holes, this does not give so good a cutting angle to the edge. These plates usually run up to $\frac{1}{8}$ in. full and are called **Clock Plates.** They have from six to twelve holes in them.

Dies for Screwing. Screws up to any size can be cut with dies, although in practice there is a limit to the power that can be applied consequently to the size of screw cut. Dies are of many shapes, the most important are as follows :—

Split Dies. These are the old shape, and are very popular as they allow the screw to be cut a little larger or smaller than the standard, but this is a bad system of working, absolute accuracy is the basis of modern machine construction ; their only advantage is in cutting threads on pipes for gas, &c. work, as the screw has to fit brass fittings, &c. coming from various parts of the country, and screwed in the lathe.

Solid Dies. The best dies for ordinary work and the easiest to make are solid dies, or really a screw-plate with one hole only, these may be with three clearance holes, which is a good working shape and cuts both ways, or for smaller dies two clearance holes.

Die Stocks vary in size to suit the dies, the principal shapes will be found in the diagrams, but it should be remembered that any holder for a loose die is a die stock, although sometimes called a screw-plate merely because it is flat.

Taps. A tap is a screw of good steel, well tempered, a portion being cut away so as to leave a cutting edge, and tapered so as to enter the hole to be screwed.

Flats on Taps. The cutting edge of the smallest taps is given by cutting three or four flat surfaces on them, this is because these very small sizes are too small to be fluted, and should never be done with any tap large enough to have a groove cut in it.

Fluted Taps. Taps intended for real work are fluted with two or more channels cut lengthwise to give cutting edges. The shape of the channel varies in different makes, a variety of them are shown in the diagrams. The Whitworth with three semi-circular flutes is

in general use, and is certainly stronger than the others, it also cuts both ways. When a tap has to be made by hand the flutes are cut with a file spirally round the tap, as it is very cifficult to cut flutes lengthwise by file. If a small emery wheel can be used it will be found just the thing for cutting either spiral or straight flutes, also for sharpening taps, great care being taken not to overheat the tap. Taps are not all same shape, there are three principal shapes in use.

Taper. The taper in which a portion is cut away so that the thread is full at top of tap, but tapering off so that very little of the thread remains at the bottom, this is to allow it to enter the hole to be screwed while the increased thread higher up cuts the screw gradually and with less risk of breakage than a full thread, while the top of tap having three or four threads full size finishes the work. When screwing work that allows the whole of the tap to go through, this is all that is required.

Plug. Many holes do not allow the upper part of taper tap to cut the full thread. For these a plug tap is used, this has very little cut away at the bottom, having full thread nearly all the length.

Other Taps. Another shape is the bottoming tap giving full thread to the bottom of the hole. Master taps are made purposely for cutting dies, and are a shade larger than the ordinary taps. A special tap consists also of drill and reamer, so that one tool drills the hole, clears it and taps it ready for the screw, this is used for gas-fitting to the main.

Tap Wrenches are required to hold the tap while in use. Several shapes are shown, some being merely a flat piece of steel with two holes cut in it to fit square on tap, others are adjustable for size, but in any case it is necessary that the wrench should fit properly and hold firmly, otherwise the square at head of tap will be spoiled.

SCREWING AND TAPPING.

Preparing Work. The material intended to be screwed must be clean and free from scale or dirt, it must also be of the proper size and regular in shape throughout, any increase in size will cause the work to jam in the plate or die, and if force is used will break off, at the same time damaging the die or plate. A Template should be made, having a hole in it for each size die or plate hole in stock, and the work tried with this before screwing. A table will be found further on giving the correct sizes of drills to be used for holes to fit each size of tap from sixteenth-inch upwards, also screwing sizes.

Screwing. Taper off the end of the intended screw so that it enters the hole in the plate or die, grip firmly either in pipe-vice or cheeks, not too far from end or in thin work the unscrewed part will bend, place the plate or die on the tapered end of the work, and with steady but light downward pressure move the tool round, as if screwing a nut on a bolt, but NOT with continuous motion, unless the cutting edges are in the best possible condition. It is always safer to give a to-and-fro motion, moving back a half-turn, then forward a little more than half-turn, the difference being the amount cut. **Use plenty of Oil** and be special careful to keep the plate or die quite square in relation to the work, too much pressure on one side will produce a **drunken screw.**

Pipes, &c. When screwing pipes with split dies, set the dies open so as to admit the pipe, place on pipe level with the end, then tighten so as to give a slight grip, screw with a to-and-fro motion till screwed as far as required with a very slight thread, then when dies are near end of pipe, tighten a little and go over again, to deepen the thread sometimes a third cut is required, but this depends on the fitting to be worked to—a pipe can be tapered at end this way—caution must be used not to grip the pipe too firmly or it may flatten out of shape, especially brass tubing which should always be held in cheeks.

Tapping, or inside screwing, requires more care than outside screwing, as carelessness will cause a tap to break in the hole, not only spoiling the tap but giving great trouble to get the broken part out. The hole must be quite straight if of any length, otherwise the tap will jam and, if force is used, break off. A hole for tapping must be drilled for tapping size as shown in table. A template should be made and the drill tested before drilling the hole. In a deep hole it is better to drill a shade smaller, then open out with a reamer which ensures correct bore, insert the end of taper tap, and work with the to-and-fro motion as described in screwing, remove tap occasionally to clear away the chips, when screw is deep enough follow if required with plug or bottoming tap. When hole is not through the metal and thread has to go deep down, make sure that extra depth is allowed in drilling or the loose chips will jam to a solid mass and be troublesome to remove. When tapping cast iron, the drill hole must be larger than for other metals, as the cast iron does not allow a full thread to be cut on it, being too brittle.

KEEP THE TAP COOL. OIL WELL. USE SLOWLY.

Broken Taps. When a tap breaks in the work there are several ways of removing it ; the following methods may be tried :—if one part projects it can often be gripped with hand-vice and screwed out, the difficulty is when it is in a casting in which the hole does not go through. A blow-pipe or other heat may be got on to the part till red hot and allowed to cool slowly, this will soften the tap, and a slit being made with a hack-saw, the bit unscrewed with screw-driver. Sometimes after softening a hole has to be drilled in a bit, and when deep enough a square-ended tool will get grip enough in the hole to unscrew the bit, or a hole drilled through, then most of the bit cut away with round file, a dead hard drill will drill a tap without first softening it, but it is very slow work and not used except when all other means fail. When the work is small the bit can be softened by placing on a piece of iron of large enough size made white-hot. In some cases there is no other way than to break up the bit of tap by hammer and hard punch. In small jobs a rose bit can be used to cut away the metal round the bit, and the resulting hole plugged and then drilled afresh to old size.

Broken Screw in Plate. This is comparatively easy to remove as it can be drilled out being soft, but precaution must be taken or the drill will slip and spoil the thread of die—the hole need not be large. Screws are sometimes jammed in plate or die by working without sufficient oil, and portions get burnished on if brass.

Making Blank for Screw. An odd screw blank can easily be made without lathe if of small size. Select a bit of rod or wire the size of intended head of screw, grip firmly in hand vice, or if small enough in pin-vice, allow as much to project as is required for body of screw, rest the projecting rod on filing rest and the file on it, with safe edge against the vice ; turn the vice and rod slowly towards you with left hand, while the file is pushed forward with the right hand. With a little practice a blank can be cut nearly as true as if turned, cut off with hack-saw, leaving as much head as required and nick for screw-driver.

Cheeks. Brass tube or rod must be gripped between cheeks ; these are easily made. Select two pieces of mahogany or other strong wood say six inches long, four inches wide, and one-and-a quarter inches thick ; cut two or three grooves in each, so that when laid together the two form a block having two or three tubular holes running through lengthwise ; make as many of these as you are likely to require, for various sizes of tubes the hole being a shade smaller than the diameter of tube, these cheeks are gripped in a joiner's vice.

Cutting off Rod or Pipes. There are two kinds of tools in use for cutting off pipes or rod iron. One, working with one or more wheels, this does not actually cut the pipe but forces the metal apart, raising a ridge by the pressure of the wheel of hardened steel, but this tool quickly divides any ordinary pipe ; it must be used with great care on brass tube or will contract the end while cutting. The other shape is of similar build but has a cutter instead of pressure wheel, and actually cuts the pipe leaving a clean end, but it is more expensive, requires greater force and is slower to work. Rod or bar iron need only be nicked round with file or chisel, and can then usually be broken off easily, but the amount of metal removed in nicking is of less importance than leaving the bottom of the nick sharp.

Hack Saw. Rods or pipes of iron or brass are easily cut with a hack-saw. The blades are very cheap and cut freely.

Pipe Threads. Iron and brass pipes for gas, water, and steam purposes, are screwed with a different pitch of thread from that used for ordinary metal screws. That on an iron pipe is the coarsest and strongest, but the threads are too deep for brass tubes, so that there are two pipe threads in use, the one for iron gas-threads, the other brass gas-threads, it must also be remembered that iron pipes are called by the inside measure, while brass is named by outside measure, $\frac{3}{8}$-in. being same size as $\frac{1}{8}$-in. iron. Many fittings in brass can be had screwed for either brass or iron—see tables.

Long Screws, &c. In connecting the ends of piping, both of which are fixed, the interval is made up with a length of pipe to the full length with the assistance of long screws and lock-nuts.

Breaking a Joint. Where iron pipes have been fitted a long time the joint is usually rusted together too firmly to be unscrewed with tongs, &c. To loosen the joint hold a heavy hammer to one side of the coupling and hammer well on the other side till the jarring breaks the joint.

Pipe-Joint. To make joint rub a few threads of hemp with white lead and lap in the threads of screw at end of pipe, the coupling will jam up tight.

Pipe-Tongs. Many shapes of pipe-tongs are in use from pocket size to very large ones, but make-shift has often to do the work. A rope twisted several times round the pipe will with a lever, turn most pipes. Another way is to jam a bit of old file with wrench.

Brazed Threads. Square threads for vices, &c., were at one time, made by brazing. A strip of nail rod (square section iron) was heated to red, then lapped round a mandrel and carefully adjusted; when cool it was, after a little more correction, brazed on, then another was lapped round between the threads and quickly cooled before it had time to loosen the brazing, it could then be screwed off and was brazed inside the nut or box of vice.

Pitch of Screws. The number of threads to the inch is called the pitch of screw, so that twenty-thread pitch means that the nut would have to be turned round on bolt twenty times before it moved along the space of one inch. Tables of pitches are given below suitable for various classes of work. Those most important are the Whitworth or Lancashire threads, being the pitch in use for most ordinary purposes, also iron-gas and brass-gas. There are some special threads for cycle fittings as bottom bracket and ball race, and for optical instruments.

Care of Tools. Screwing tackle is expensive, and if it has to do its work well must be carefully treated. Taps must never be put into dies. A shallow box should be fitted with partitions of soft wood, one for each die or tap in stock. This does not take very long to make. It will pay to have it made specially by a joiner, as the cost will soon be saved by the quick work done with tools in good order. Taps, especially if kept so that they touch one another, soon lose their cutting edge.

What to make and What to buy. A set of plates, stocks, dies and taps, to screw from smallest upwards, is an expensive item in a small shop. It is advisable, where cost is to be considered, to buy a screw-plate and taps to work up to one-eighth inch for small work, models, &c., and from one-eighth inch up buy the taps only, and make plates and dies. The taps sold with the screw-plates might be treated as master taps and put away, another set being made from the plate for use, and another plate when required from the *unused* master-taps. For sizes over one-eighth inch the taps should be bought unless there is a lot of rough work to be done, when other taps can be made. Taps are very cheap compared with dies, a ¼ in. fluted tap of good quality can be bought for one shilling. With this a solid die is easily made, so is a die-stock to hold the solid dies, but there is no use making a die with a tap that has done a lot of work, it must, for such purpose, have sound cutting edges.

MAKING SCREWING TOOLS.

Making Taps. It is a mistake to make screwing tools out of any but the best quality of steel. They can be made from old files, but

tool steel is too cheap now to make it worth while to have an inferior tool for so small a saving. The steel is sold in most sizes for taps, so that there is also a great saving of time. The large sizes over ¾ in. must be turned in the lathe to size. Screw the piece of steel intended for tap just as other work, going over it slowly and with plenty of oil. When screwed it must be filed up. If for taper tap, file three-quarters of the length so that at the bottom there is scarcely any thread to be seen, while three or four threads remain at top, this is to allow it to enter well into the hole and get a good grip. Next file three or four flats on the side the whole length of the screwed part, removing one-eighth of the surface for each flat. This will do for small taps, but for those over quarter-inch two grooves or flutes must be cut. If this has to be done with a file the flutes must be spiral. Diagram shows details of it—this gives a good cutting edge—then file a square on head for tap wrench to grip and it is ready for tempering. If a small emery wheel is at hand cut three flutes as shown in diagram, the emery wheel will also be very useful for sharpening an old tap, but it must be correct shape at edge. The steel should be annealed before using.

Making Dies. It is not advisable to attempt making split-dies, if it is possible to do the work required with solid ones, they are much more difficult to make and not so strong. Take a piece of good tool steel, one-inch square, quarter-inch thick, for quarter-inch die, select drill of tapping size, mark centre of block, also three other places each rather less than quarter-inch from centre, drill the three outer holes and plug them with soft iron, then drill centre hole and tap it. Remove the plugs from the outer holes and they will be found to have cut into the screwed hole. The die must now be dressed with a fine ward-file at junction of the holes, and with a round file cut some of the thread at lower part of die so as to taper the hole. Some workers taper the tapping hole before screwing it.

Split Dies. Cut grooves on sides of die block to fit the ridges on stocks—this must be done with the utmost exactness as the whole working depends on the exact fit—drill and tap as in a solid die, then cut in two with a hack-saw and dress with file, (diagram shows the best shapes for split dies), mark with centre-punch or otherwise the sides of die, so that they do not get misplaced when inserting in stocks.

Screw Plates. These can be made from old files, which may also be used to make a solid die with handles complete in one piece. Heat to full red heat, then bury in hot ashes so that it cools slowly, test with file to see if soft enough and repeat if required, file or grind off roughness, mark parts for drilling, then proceed as directed for solid die. The best shape for cutting edges to hole is shown in diagrams.

Tempering. The taps, dies, and plates having been made as directed, now require hardening and tempering. First fill the threads with hard soap to avoid scale and keep them clean ; heat a large block of iron in fire to nearly white heat, remove and place the tools on it, when they reach cherry-red lift off and, keeping taps in an upright position, plunge in water, if slanting they will twist. Dies must be

dipped flat. When cooled, clean up a surface with emery or fine stone, (pumice does well), place again on hot block till the head of tap shows light blue, dip the head only in water, quickly remove and replace tap on hot block, allow to heat till the cutting part is a LIGHT CHESTNUT BROWN, then quench in water. Dies are treated the same way as taps. Dark straw color gives a good temper with some grades of steel. It is convenient to hold the head of taps in tongs while re-heating. A tap bent in tempering can be straightened by heating and careful pressure with hardwood—should not be heated high enough to show any color.

Makeshift Tools. An ordinary iron nut having a good full thread may be cut away to give sharp cutting edges, and case hardened, will serve as a die. A screw bolt may be treated in the same way and used as a tap, but these will not bear using many times.

When one of a pair of split dies is lost, its place may be taken by half a nut of same screw thread.

(Instructions for case hardening are given in Section "Tempering and Case Hardening."

Left-Hand Screws. These are not often used, but are sometimes required. To make a left-hand tap:—screw a bit of tool steel, then file it away both sides so as to leave only a thin strip having its edges screwed, the lower end should be gripped in the vice and the top twisted so that the strip has a half-turn to the left. When tempered this will, if used with care, cut a left-hand screw using it in the opposite direction to the ordinary tap.

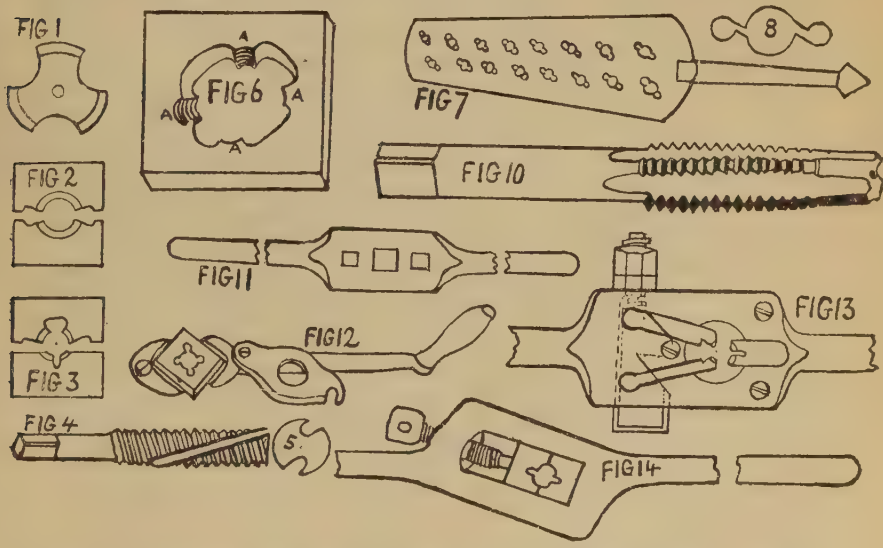


Fig. 1—End of Whitworth Tap. 2 & 3—Split Dies. 4 & 5—Hand Fluted Tap. 6—Solid Die. 7—Clock Screw Plate. 8—Best shape of hole. 10—Fluted Tap. 11—Tap Wrench. 12—Solid Die and Stock. 13—Whitworth Die Stock. 14—Engineers' Die Stocks.

Whitworth Standard Threads, Tapping Hole Drills and Pitch.

Diameter of Tap	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2 ins.
Drill for Hole			$\frac{1}{10}$	$\frac{1}{7}$	$\frac{3}{16}$	$\frac{15}{64}$	$\frac{9}{32}$	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{21}{32}$	$\frac{27}{32}$	$\frac{15}{16}$	$1\frac{1}{16}$	$1\frac{9}{32}$	$1\frac{1}{2}$	$1\frac{45}{94}$
Threads to one inch.. ...	60	48	40	24	20	18	16	14	12	12	11	11	10	9	8	7	7	6	5	$4\frac{1}{2}$

Standard Threads for IRON Pipe, Gas & Steam.

Diameter top of thread	$\frac{13}{32}$	$\frac{17}{32}$	$\frac{21}{32}$	$\frac{13}{16}$	$1\frac{1}{32}$	$1\frac{3}{32}$	$1\frac{21}{32}$ in.
Bore of Pipe	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$
Threads to one inch ...	28	19	19	14	14	11	

All over 1 in. bore eleven to the inch.

Brass Tubing Threads.

Brass and Copper Tubes are screwed with a finer thread than is used for iron. The taps and dies are made for $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1 in. The sizes are reckoned from the OUTSIDE diameter of the pipe, NOT THE BORE. $\frac{1}{8}$ Iron Pipe equals $\frac{3}{8}$ Brass.

Alloys for Tempering.

Color	Melting Heat.	Alloy. Tin.	Lead.
Light Straw	430° f. ...	1 ...	$1\frac{3}{4}$
Dark ,, ...	470° f. ...	1 ...	$2\frac{1}{2}$
Brown Yellow	500° f. ...	1 ...	$4\frac{3}{4}$
Dark Purple	550° f. ...	1 ...	12

Bath of Linseed Oil and Thermometer is a better method.

Tests for Steel.

Nitric Acid leaves a dark grey spot on Steel.

,, ,, Cast Iron black.

,, ,, Wrought Iron bright.

White heat disentegrates good Steel.

Bright red heat causes steel to crumble under the hammer.

Mid red heat right for working steel.

Tools and Materials for every description of Metal Working may be had from M. COLE, 20, Northen Grove, West Didsbury, Manchester.

COPYRIGHT

METAL DRILLING,

Drill-Making, Tempering and Using.

By M. COLE.

* * * * * *

There are two principal classes of metal drills—the **Cylindrical** and the **Spear Headed.** In the Cylindrical drill the body of the drill is the full size of the hole to be bored, the body acting as a guide to keep the point of the drill in its right place, so that a hole bored by a cylindrical drill is quite straight. In the older forms two flats or grooves were cut in the body of the drill to allow the drillings to escape. The Twist drill is another form of this and has two spiral grooves instead of the straight ones, these bring the drillings to the surface. The Twist drill is certainly the best shape for getting through the work well and quickly, but it has its drawbacks, as it cannot be ground except by special appliances, and any attempt to do so by hand spoils the drill. Another difficulty is that unless run very true it jams, and if small, breaks. To these drawbacks must be added a much higher price, so that unless used in a good lathe, or true running drilling machine, the other styles are preferable.

Spear Headed Drills. This is the ordinary shape of metal drills, and until comparatively recent years the only one. The body or shank of such size that it fits the chuck or drilling machine is narrowed down to form a neck, then widened and flattened to a head, all that part that goes into the deepest hole to be drilled being smaller than the width of the point. Good well made drills are so cheap that it is hardly worth while to make them, though so much is to be learned by making a drill that the time is well spent.

Selecting the Material. Drills like other cutting tools should be made from the best tool steel, and it is not dear, but it often happens that a drill is wanted and no tool steel is to be had. It should be remembered that any metal if properly shaped will cut any other piece of metal not harder than itself. Old files or other tools of good quality steel may be used for drills. In the manufacturing districts of Lancashire and Yorkshire old mill spindles are to be had very cheaply. They vary from 6 to 24 ins. long, and proportionate thickness, are perfectly straight, so that if the end is worked into a spear head and a length cut off, a drill can be very quickly made, but they are a very mild steel and should not be used if the proper stuff is to be had. Steel varies in the amount of carbon it contains, some being as low as ½ per cent., others up to 1½ or more, and the quality suitable for a razor would not do for a drill.

Shaping the Drill. The Spear Head drill is of three parts—the **head** or cutting part; the **body** or **shank** being the part held in the chuck or socket of the drilling machine; and the tapered **neck** connecting the two others. The **head**, which is the most important part as it does the work, is usually 90° angle, and should be tapered at

the point according to the size of drill. The **neck** is the part just above the head and is smaller than the hole the drill will bore. If the neck as far as it penetrates were the size of the hole, the drill would be cylindrical. The **body** or **shank** is the part that fits the chuck or socket of the drilling machine by which motion is imparted to the drill, and may be either **square, cylindrical,** or **taper.**

Square body is required only when the drill is used in a joiner's brace, a very convenient method when lathe or drilling machine is not handy, but a large hole should not be attempted, not larger than $\frac{5}{8}$" in brass, or $\frac{3}{8}$" in iron: if required larger, the hole should be opened out with a reamer used in a brace,

Cylindrical. This is the most useful form for the body of a drill when used with a self-centreing chuck, or in the socket of a drilling machine, but in the latter case a flat must be filed or ground on it so that it may be tightened with a set screw. This is the old style, and from its shape difficult to get a drill to run accurately. If the drill is an exact fit to the socket, the ordinary treatment and occasional knocks would soon make it difficult to insert, and if forced in impossible to remove, for this reason a little play is allowed with the result that it is not concentric.

Taper. The body or that part of it that is inserted in the socket is tapered, and the socket itself is bored of an equal taper. This gives the best of all fits, and is used in the best makes of Twist drills.

HARDENING AND TEMPERING.

Steel may be hammered more than iron, but with light quick blows, gradually with less force as it gets cooler and not with much force after it has lost its redness. It must not be heated higher than a bright red heat, and care must be taken that the fire is clean and free from sulphur fumes, coke being preferable to coal. A length of iron pipe may be used in the fire to keep the tool clean while heating. Steel is improved by hammering at the right heat, but spoiled if hammered at too low a heat Frequent heating also spoils it. Sharp angles must be avoided, as that is where cracks usually start.

Tempering the Drill. For some reason that has never been explained, when a piece of steel is heated to redness and quickly cooled, it is hardened, so much so that it will break like glass if dropped on a stone, but if the same piece of steel is then re-heated to a lower heat than before and cooled, it is no longer so brittle, but more or less springy, being then tempered. If it were not for its brittleness, a drill that is dead hard would be the ideal one for cutting as it would keep its edge As it is we are compelled to use a tempered drill, which, though less hard, is tough enough to stand working. Steel changes colour with the degree of heat to which it is subjected, but it should be remembered that while the degree of temper denoted by a certain colour is always the same for the same quality of steel (provided it has previously been equally hardened) the same colour would show various degrees of temper for different qualities of steel. Again, colour does not prove steel to be tempered. If a piece of soft steel be heated to straw colour and quenched, it will not have the same temper as if it had previously been hardened. The colour is caused by a thin film of oxide. (*See Table A.*)

Process of Tempering. Heat the tool to blood red when looked at in a dark corner, then dip in cold water holding the drill perfectly straight, point downwards, keep there till cold, it will then be quite hard and brittle ; now clean up one of the surfaces of the head with a flat stone, and re-heat till it shows the desired colour, at once dip in water and hold there till cold, keeping the tool perfectly straight ; it is then ready for grinding. It is as well to rub the surface that is to show the colour with a piece of stone while hot to clean it.

Hardening and Tempering at one operation. Grind a smooth place on the body of the drill, and another on the head, heat to red and then dip the head and half of neck till the body shows light blue colour, lift out of the water and hold till the heat of the body of drill spreads to the head and shows the right colour, say light straw then quench the whole drill. Once in the water a tool must not be lifted out till cold. The steel is white when dead hard and cold. A good process of tempering much used in U.S.A.:—Heat the tool in a clear fire and while hot rub on some common yellow soap, then heat to cherry red, and quench off in some common petroleum. Keep away from the fumes. Everyone thinks his own method of tempering the best. Below are opinions of practical men on the best way to do it, they are all useful though contradictory :—

"Boil the water before using."
"Spray the water on the drill."
"Use water heated to 100° F."
"Put a little oil on the surface."
"Put plenty of salt in the water."
"Use pure clean water quite cold."
"Keep the drill perfectly still in the water."
"Move the drill gradually lower in the water till cold."
"Dip the head and hold 10 secs. before dipping the remainder."

Good work has been done by all the above methods and they are *all the best way* according to those who use them. When re-heating a small drill for tempering use a block of iron, large in proportion to the size of the drill, heat to redness, then lay the drill on it, the head overhanging, the block will heat the drill. A very tough result is got by "Blazing off," not so useful for drilling, but very useful where it is necessary to have a drill that will spring rather than break. After heating drill, dip in cold oil to harden it, then put the oily drill in the fire till it blazes up, allow to blaze till the right colour is reached, then quench off. When tempering a spring allow to blaze till burnt out, then dip in water. When large quantities of articles are to be tempered they are often done in an oil bath, which can be kept at the required temperature by a thermometer. Linseed oil boils at 600° F. and mercurial thermometers can be had graduated to 600° which is much higher than is required for tempering.

Grinding is a very important part of drill making. The small cutting edge is the part that does the work, and the most elaborate lathe, chuck, drilling machine, &c., is only a means of moving the unseen and often forgotten cutting edge. The usual angle for a drill is 90°. When required for cutting very hard metal or glass, the angle is smaller, while for thin metal a much larger angle is used,

sometimes nearly straight. The object of grinding a drill is to give it a cutting edge, so that if one side is ground away more than the other only one side will cut, and the drill will only be doing half its work, a little clearance must be given but only enough to prevent any part except the cutting edge pressing on the work, so grind away only a little more than the depth the drill is intended to cut. 1ooth of an inch is a good cut for drill of moderate size. If too much is ground away, the edge is weakened and breaks. When a drill is properly ground, the drillings should come away in curls ; in one badly ground or dull they are only scrapings. There is one part of the drill that does no work, viz:—the point. A great deal of the power put into the drill is used in forcing the point into the metal. This is even more marked in twist drills. Many devices have been tried to get over this difficulty. One of the best is shown in the diagram. If a small leading hole, say $\frac{1}{8}$ in. for drills up to $\frac{1}{2}$ in. is first bored, the drill may be run at double the speed that could otherwise be used with it.

A Grindstone is the safest to grind drills with, but it must be kept true, and not allowed to wear into irregular shapes, as many grindstones do. An emery wheel does the work much quicker and runs truer, but there is always the danger of burning the edge of the drill unless it is kept flooded with water, merely wetted is not anough to ensure safety. It is worth while to finish off with an oilstone, the superior edge is worth the extra trouble.

Testing the Drill. To see if correctly ground, run the drill very slowly so as to drill into a bit of brass, and watch if both sides cut ; if only one side cuts the work will take twice as long to do, and the drill be forced sideways—if small the drill breaks, if large the strain injures the chuck.

Drills ground by hand in the ordinary way are never accurate except by accident, so the greatest care should be used to get the error as small as possible.

Case Hardening. In an emergency it is sometimes necessary to make a tool of wrought iron instead of steel, the *surface* may be converted to steel by case hardening. Take equal parts of Prussiate of Potash, Sal Ammoniac, and Salt. Powder and mix them. Heat the iron to a bare red heat, dip in the powder and put in the fire so as to melt the mixture, remove and repeat process several times, then raise to a full red and temper the usual way. Another process is with leather cuttings, but although better it is too slow for emergency work.

Making very Small Drills. Drills can be had ready for use down to the smallest required by watchmakers. To make them it is best to use good steel wire, failing that they may be made from needles—sewing machine needles being the best as they are well shaped and only require a head making, the body being large enough to be held in a drill chuck. To soften, heat a large piece of iron to redness, lay the needle on it—it will soon reach the heat of the block —allow both to cool together, the larger the block the softer the needle will be. Now break or file off the point and with *one* blow of a hammer spread the end to form a head. It will stand one knock

but repeated hammering will spoil it, file and dress to size, then to harden hold the drill with pliers, heat to redness in the flame of a tallow candle and instantly plunge the point in the tallow. It then only requires setting on an oil stone. Mercury may be used to quench the drill to get a very hard point.

MOST IMPORTANT.—If the head of a drill has been overheated, it should be cut off and a new head forged, as no good can be done with burnt steel.

CHUCKS, DRILL STOCKS, &c.

In their earliest forms, metal drills were only pressed against the work and turned to and fro by hand (though a form of bow drill was used by the ancient Egyptians), but it is obvious that this method is too slow for modern times. There are two methods by which a drill may be moved, viz: **Continuous** and **Reciprocating**. The former is of course the preferable one, as in that case the drill cuts all the time it is moving, while by the latter it cuts only when moving in one direction, the time used in the return stroke being wasted. The fiddle, bow drill, watchmakers' turns, and Archimedian drill-stocks belong to this class. The bow drill in its various sizes is the easiest to make. In its simplest form the drill itself has a pulley or bobbin on which the cord of the bow works to give it motion, while the upper end of the drill is pointed and rests in a countersink in some suitably placed piece of metal. In small turns this is usually the end of the bench vice, the work being supported on a suitable block to bring it to the right height; or the work may be placed against another point in the same plane as the drill. In larger sizes it rests in the countersink of a plate of metal placed against the breast of the worker, who can thus apply pressure to the drill; this is, however a very dangerous method and should be avoided. The Archimedian drill stock is much safer. In all drills of this class there is some difficulty in keeping them perfectly steady so as to drill a straight hole to any depth; they are, however, useful for thin work. The Swiss drill is used upright and can easily be fitted with a bracket to keep it in position so as to do accurate work. It is only suitable for small holes, as there is only the weight of the tool to keep the drill up to its work. The **Continuous** motion drill is in every way to be preferred. All modern drilling machines and drill stocks belong to this class.

Chucks. Except in the simplest form of bow drills, &c., the drill is separate from the tool that gives it motion, and is held either in a socket that takes one size drill body, or in a chuck that will take various sizes. The Bell chuck is one of the earliest styles of adjustable chuck, and is one of the most dangerous tools ever made. It is a cup-shaped piece of metal, the small end of which fits the screw of the lathe. The larger part is fitted with 6 or 8 set-screws to hold the drill, the heads projecting. If this is used, a cover of sheet metal should be made to avoid accidents. The Self-centreing chuck is the best and most practicable method of holding a drill.

These Chucks are now very much lower in price than they were a few years ago, and can be had in all sizes, from the smallest used by watchmakers, to those required for drilling the heaviest work. They

can also be used for drilling work in the lathe between the centres. The shank end of the chuck resting against the running centre, and carried round by a dog or carrier, the work being held between the point of the drill and the back centre for light castings ; where heavy work is to be drilled, it must of course be supported in the usual way.

Boring and Drilling in the Lathe. When the chuck (of whatever form) is fixed to the head of the lathe, the result is really a horizontal drilling machine, but when very accurate work is to be done the drill should rest against the running centre, and be carried round by a dog or cramp fixed to it, and driven by a pin on the face plate. When the work revolves instead of the drill the process is boring, whether the cutter is the full size of the hole as a drill, or smaller and attached to a rod as in a boring bar.

Joiners' Brace and Drills. For odd jobs a joiner's brace of modern pattern fitted with jaw chuck will do a large range of work. The drills have a square shank and fit well in the chuck. Twist drills should never be used in such a brace as they are liable to be strained. Holes up to $\frac{1}{4}$ in. in brass, or $\frac{1}{8}$ in. in iron, are easily drilled with a brace. For larger sized holes, a leading hole should be drilled first, say $\frac{1}{8}$ in., then follow with a larger drill. Those braces fitted with ratchet have the extra advantage that the hole can be drilled in places where there is not room enough for the sweep of the brace. As a good deal of pressure is required to prevent the drill slipping when drilling the larger holes, it is necessary to rig up some arrangement to get the pressure by a lever. This is easily made from a few lengths of wood. One disadvantage of this method is that the pressure is indirect, being transmitted through the arm of the brace, which bending a little under the pressure throws the drill out of truth. Chucks like those used in the brace can be bought separately and fitted with some sort of screw to get pressure. If fitted with one of the new ratchet nut wrenches costing about 2/-, a powerful drilling jig can be made very cheaply.

Drilling Hard Steel. It is sometimes necessary to drill a hole in hard steel. In tempered steel this can be done with a drill left dead hard, but the utmost care must be used not to put on much pressure or the drill will break. If the steel is too hard for this, a splinter of either diamond or corundum mounted as a drill must be used, or it may be done with a copper rod fed with emery powder. In this case a guide is made from a bit of wood with a hole in it the size of the drill, cramped on the work so as to keep the drill in its place. Feed with emery of moderate fineness, and use oil to keep it in place. The grains of emery will bed themselves in the copper, but the pressure is not great enough to force them into the iron.

Very Small or delicate work should be held in the fingers, the hand resting on the work-bench or other support. A bow drill is best for this, the pointed end resting in a hollow in the side of the vice or other fixed object. There is so much flexibility in this arrangement that breakages seldom occur. The hole is afterwards rectified with broaches, which can be had in all sizes from the size of a fine needle upwards.

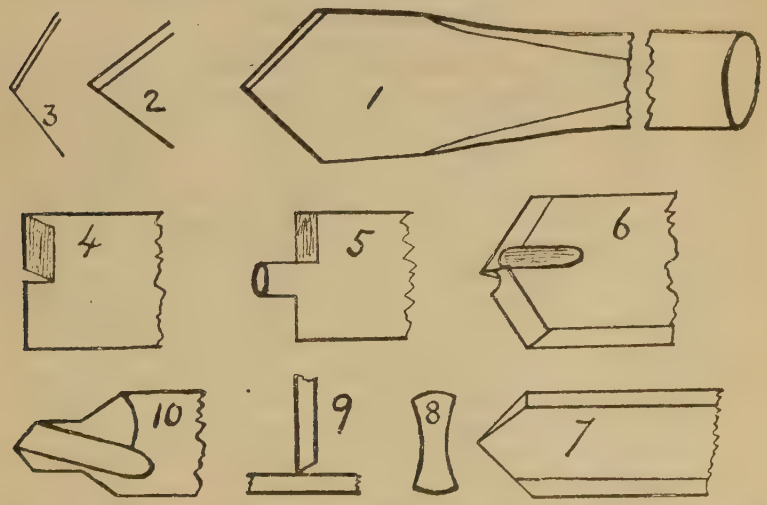
Drilling a Hole in a Ball is not difficult if the work is properly held. To make a ball cramp, bore holes of various sizes in two

pieces of wood held together, when separated the ball can be put between a pair of holes of size smaller than itself. The boards, when cramped together, will hold the ball firmly and without injury if reasonable pressure is used. Pearls are thus held for drilling, either through for beads or half through for mounting as pins.

Drilling Glass. Holes can be drilled in glass with ordinary steel drills as used for metal, kept cool with either turps or paraffin oil, but the glass is broken off in fragments rather than cut, To start the hole, rub the glass at the place to be bored with a bit of emery cloth, then tap gently with a sharp pointed bit of hard steel, until a hollow is formed deep enough for the drill to rest in and get a grip of the glass, then proceed as in metal drilling, but using slow speed. When half way through reverse the work and drill from the other side to complete the hole, which can be opened to square or other shape with a file kept wet to prevent heating.

Diamond Drills are made from a splinter of the outer crust of the diamond, which is much harder than the inner parts used for jewellery. To mount it drill a hole in the end of a piece of brass wire, insert the splinter of diamond and fill up with soft solder, then remove as much as is necessary to expose cutting surface. It must be used carefully as, although it is the hardest known material, it is very brittle and easily broken. A fragment of corundum is almost as good for the purpose. The diamond drill is usually kept wet with turps to prevent the heat produced softening the soft solder.

Drilling Fluids. Use soapy water for wrought iron ; oil for steel.



Explanation of Diagrams.—(1) Spear-head Drill, the usual angle of 90° (2) Narrow Angle for hard metal. (3) Large Angle for thin metal. (4) Flat-end Drill for flat bottom hole. (5) Pin Drill for flat bottom or for surfacing round a hole. (6) Method of reducing size of idle point. (7) Channel Drill. (8) Section of ditto. (9) Cutting edge on work. (10) Combined Drill and Countersink for work to be put in lathe.

TABLE A.—Compiled 100 years ago and still unsurpassed.

430°F.	—Faint Yellow	Lancets
450 ,,	Pale Yellow	Razors
470 ,,	Full Yellow	Penknives
490 ,,	Brown	Scissors, Cold Chisels
510 ,,	Brown, with Purple Spots	Axes and Planes
530 ,,	Purple	Shears and Table Knives
550 ,,	Light Blue	Swords and Watch Springs
560 ,,	Full Blue	Small Saws
600 ,,	Dark Blue	Hand Saws

TABLE B.—Colors of Finest Tool Steel at various heats.

430°F.	—Very Pale Yellow	Gravers, Drills, Light Turning Tools
457 ,,	Straw Yellow	Paper Cutters, Milling Cutters
495 ,,	Brownish Yellow	Taps, Punches, Reamers, Twist-drills
528 ,,	Light Purple	Plane Irons, Wood Tools
535 ,,	Dark Purple	Wood Chisels
570 ,,	Clear Blue	Screw-drivers, Springs
600 ,,	Dark Blue	Saws for wood
610 ,,	Pale Blue	,, ,,

Tools of awkward shape should be heated in Linseed Oil which boils at 600°F. so that the tools cannot be overheated.

TABLE C.—Speed of Twist Drills compiled by the Morse Twist Drill Co., U.S.A.

Diameter.	Speen for Steel.	Speed for Iron.	Speed for Brass.
$\frac{1}{16}$	1712	2383	3544
$\frac{1}{8}$	855	1191	1772
$\frac{3}{16}$	571	794	1181
$\frac{1}{4}$	397	565	855
$\frac{5}{16}$	318	452	684
$\frac{3}{8}$	265	377	570
$\frac{7}{16}$	227	323	489
$\frac{1}{2}$	183	267	412
$\frac{9}{16}$	163	238	367
$\frac{5}{8}$	147	214	330
$\frac{11}{16}$	133	194	300
$\frac{3}{4}$	112	168	265
$\frac{13}{16}$	103	155	244
$\frac{7}{8}$	96	144	227
$\frac{15}{16}$	86	134	212
1 in.	76	115	191

COPYRIGHT

Metal Surface Finishing.

How to use Chipping Chisel and File. Draw-filing, Scraping, Polishing, Burnishing, Figuring and Lacquering.

By M. COLE.

* * * * *

Cast Metal comes up rough from the sand of the mould, brass being rougher than cast iron, as the iron is more fluid when melted and expands a little just before setting, so takes a finer surface from the mould. Wrought Iron usually has a scale on it from the forge fire, even articles of sheet brass get rough in the process of working. When starting to clean up cast metal, the loose sand usually adhering to the surface should be removed with a brush of steel wire before using a file ; with wrought iron the scale should be scraped off with the edge of an old half-round file.

Removing the outer skin. Castings have always parts left on them where the metal has been poured, or vented. These would usually take too long to cut away with files only. When dealing with small work these can be ground off with an emery wheel, where this is not to hand, or in larger work, they must be cut away with a chisel. The skin of cast iron is very hard, and spoils a file quickly, so if not chipped away it is removed with old files that are useless for other purposes, or by immersion in Acid (pickle), which eats away the surface so as to give the files a fair chance.

Truing up the surface. A true surface plate is required if the work is to be exact, but much can be done with a single straight edge, if the edge be true. The straight-edge if applied in all directions across the surface soon shows any inequality. With surface plate a little colouring should be used. Dry Venetian Red mixed with machine oil to a thin paint is painted over its surface, the work being placed upon it, red marks show where the high parts touch the surface plate, thus showing where the metal is to be removed. When metal has been brought to a fairly good surface by filing, the next step is *Draw-filing*, or scraping with the file in one direction only.

The File and how to use it. Files are of various degrees of roughness. The principal ones are : 1—Rough, 2—Bastard, 3—Second Cut, 4—Smooth, 5—Dead Smooth. They vary in fineness with their length, for example : a bastard file of 4 in. length is twice as fine as one 16 in. long. For most work 8 in. files will be found most suitable, unless there is a special reason for using longer or shorter ones. All flat files purchased should have a safe edge, that is, one of the edges not roughened, so as to allow it to press on a shoulder or against the end of a hand-vice, which guides the file without being cut by it. To do good work the file must be used slowly. If a lot of metal has to be removed, it will be found better to use a

long file slowly than a short one quickly. Put pressure on the file during the forward stroke only, on the return stroke use just enough to prevent the file leaving the work, all pressure more than this is not only waste of energy, but spoils the file by breaking the teeth. The work must be firmly fixed, if small, in a vice ; if larger, bolted down to something firm and solid as a work bench. If not perfectly rigid it is impossible to work with any exactness. Stand in front of the vice, left leg forward, hold handle of file in right hand, end of the file in the left, work steadily, being particularly careful that the file does not travel in a curve as most beginners do, but *keeping it level through the whole of the stroke.* The harder the metal, the finer the file required. Brass and copper require a sharper file than steel or wrought iron, in fact a file that is used up for brass is in good condition for wrought iron, and after that for steel. Old files should be kept for removing the skin of cast iron, as it spoils a good file. In truing up a flat surface, do not use the file in one direction only, but go in all directions over the surface, end to end, side to side, then diagonally from corner to corner, *using the whole length* of the file, not the middle only. In using a round or half-round file, a screwing motion must be given to it during the cut, this enables it to be used with much greater accuracy than otherwise. Have a handle for each file in use, handles are cheap and it is very bad practice to remove them from one file to another.

Cleaning Files. It is important that files should be frequently cleaned, especially those used for brass and soft metals. Solder and lead in particular soon fill the spaces between the teeth, and if not removed render the file useless ; grease and dirt also clog. To clean, if greasy, put the file for a few minutes in strong hot lye, or in hot water in which plenty of washing soda has been dissolved. This softens the grease, and then it can be easily washed out with a brush made by tacking a bit of card cloth (a brush-like cloth with wire in place of bristles) on a bit of wood, or with the end of a bit of brass tube strike the surface of the file in the direction of the cuts. If a file is clogged with soft metal, it must be removed with a steel point, scraping along each cut of the file—tedious work but the only way. Although this takes time it is really quicker than working with a dirty file. Keeping the file chalked often prevents the teeth filling.

Files for ordinary use are double cut, that is, the grooves run diagonally across the tool and others across them, thus giving a raised point at each intersection of the cuts. Saw files are single cut, the result being ridges diagonally across the file and no points. These are not so useful for getting up a surface, but are easier to keep clean, and can be used when double cut are not at hand.

Draw-filing. In draw-filing, the handle of the file should be removed, the file grasped with both hands, one at each end and held parallel to the chest, so that the sides of the teeth are used. Lay the file flat on the work and press on it only during the stroke *from* the body, pressure to be removed during the return stroke to the body. Always use short strokes in draw-filing. The filing is done at right angles to the length of the file. See that the file used is quite flat and not warped. The object of draw-filing is to remove the marks left by using the file in the ordinary way.

Scraping. When the surface is as good as filing and draw-filing can make it, scraping is the next process. The work is applied to the painted surface plate frequently, and where the two touch, the red marks on the work show where the scraper is to be used, removing only very little at the time. Scraping and testing is continued untii the work when applied to the surface plate shows an even coat of color all over. Where absolute accuracy is not required, the scraping process may be omitted. The shapes and correct way of using the scrapers are shown in the diagrams. The plain ended one is all that is required for most jobs, and is made from an old file by grinding to shape on a grindstone, and on which it must be sharpened as often as is required, as a dull scraper is useless. The other shape of scraper with turned up end is useful for getting at awkward places which do not permit the use of the ordinary shape. In grinding, care must be used that the end is ground quite straight, it it is curved it will produce inequalities instead of removing them. When no surface plate is at hand, a piece of plate glass will be found a good substitute. Very useful scrapers can be made from old three-cornered files by grinding away all the roughness on a grindstone.

Polishing. When a high finish is more necessary than accurate surfacing, the work is next polished, first with emery cloth. Lap the cloth *once* round a flat stick and use like a file. If lapped several times round it does not have a flat surface. It is best to glue the cloth to a piece of flat wood a shade larger than the cloth, this is very little trouble to do and will well repay the extra time spent upon it. Having gone over the whole surface with a steady even pressure, working from end to end, then across, repeat with a finer grade emery cloth. This will give a good polish which may, if required, be improved by using tripoli powder and water. Finish off if desired, with putty powder applied dry with the hand, rubbing with the natural pad at the base of the thumb. This gives the finest polish known, thongh such extreme delicacy is seldom required. The work has now the best finish that can be got by abrasion.

Small articles can be polished with the lathe. A disc of leather or thick felt is run at a good speed and fed with fine emery or with fine lime powder, or a nnmber of circular pieces of calico are fixed between cheeks extending to half their width, the edges of the cloth give a good polish to work held against them.

A very good polishing material is the dust from grindstones, or for fine work from oilstones ; both of these have great cutting power. A slip of oilstone used with oil or water is very useful for small work and is much used by watchmakers. The slips can be had $\frac{1}{4}$ in. wide.

Burnishing. All Metals are naturally crystalline as may be seen by examining a bit of broken metal, alloys, as brass, &c., are also mostly crystalline, while wrought iron is practically a bundle of rods or wires according to the quality, but all have naturally minute hollows all over the surface even after all that can be done by abrasion (filing, &c.) This is seen also in electrically deposited metals as silver or nickel-plated goods. To get a bright surface these hollows must be filled by the metal of the surrounding higher parts being forced into them by pressure with a smooth tool of much harder

material, steel or bloodstone being generally used. This is called burnishing and produces the high polish seen on new electro-plated goods, which however, soon disappears through the surface being worn away by the whiting or plate-powder used to clean it. To preserve the bright polish it must be lacquered.

Figuring or Curling. Large surfaces of burnished or even polished brass are not always pleasing to the eye, besides showing the slightest scratch or finger mark, so that figuring or curling is usually done on a surface that has to be handled. The work having been brought to a high degree of polish, a stick of charcoal is rubbed on the surface so as to produce the required designs ; a little practice is required to do this well, and it should first be tried on a piece of waste brass plate. A slate pencil is often used for this purpose. The size of the pattern must be in proportion to the size of the suaface worked upon. Some workers prefer to use the finger tip dipped in powdered charcoal or fine pumice powder, though putty powder is much better ; others use a leather dabber, but in all cases the work must be kept well wetted.

Lacquering is really French polishing applied to metal work, by which a transparent coat of *Lac* protects the finely polished surface from the air and from handling, but it will not stand moisture, so that lacquered goods must be kept dry. To apply the lacquer : heat the work in an oven or over a gas flame free from smoke till too hot to handle comfortably (the lacquer should give off a little vapour when applied if the heat is correct), paint on a coat of the lacquer with a camel hair brush as large as convenient, and having the end of the hair cut level, use the tip of the brush and have a bit of wire across the lacquer pot to wipe off the excess of lacquer so as not to have too much on the brush. Paint over, using the brush in one direction only, from end to end, taking great care that the coat is even all over and without streaks. The work is then re-heated and allowed to cool. Avoid too thick a coat or the effect is like gum, or too thin a coat which will cause it to have a lot of colors. See that the work is free from grease and do not touch it with the fingers, but with a clean cloth or with wire hooks or tongs.

Curved and Irregular Surfaces. When the surfaces to be worked are not flat, the proceedure must be modified to suit the shapes and curves, but it follows on the same lines as already given. Round or half-round files must be used, and emery cloth or powder on sticks of suitable shapes. Water is better than oil for this purpose, as the oil is apt to clog the powder, though paraffin oil is a good medium. In getting up irregular surfaces, scratch brushes of various shapes will be found useful, they can be used with soapy water, but they are only for getting up a finish, not for removing metal.

The Chipping Chisel. The method of using the chipping chisel will be better understood from the diagrams than by any description. The chisel must be of good steel, sharp, and the proper shape for the job. If used correctly it quickly removes a lot of metal, if wrongly used it only gashes the work. *Dull chisels don't cut.* It even pays to use an oilstone to get a good edge, though a fine grain grindstone is the proper thing for edging a chisel. An emery wheel

is excellent for the purpose, but great care must be used or the edge of the chisel will be burned. See that the chisel edge is not too wide, $\frac{3}{4}$in. wide takes twice as much force to cut as $\frac{3}{8}$in., so that the smaller will take a heavy cut while the larger one takes only a light cut. The hammer should be as heavy as can be comfortably used, if too heavy for the user there is no gain over a lighter one.

Chisels must be made from the best tool steel, common stuff will not do and is no economy. They may at a pinch be made from old files. Those used for brass may be tempered harder than those for iron, and the former may also have a more acute angle at the cutting edge. Full instructions for making and tempering chisels, &c., see Section "*Metal Drilling, Drill Making and Tempering.*"

Burnishing Tools and how to use them. Burnishers are of steel or bloodstone, shaped according to the work they have to do. The stone burnishers are small and set at the end of a long handle, these are used nearly upright, being grasped near the stone end with the fist, steel burnishers are much longer and set in shorter handles. The method of using is the same in each case. First go over the work with a steel burnisher, keeping it well moistened with soap suds made from burnishing soap, grasp the tool firmly and using as much pressure as is required to get the bright effect, run it to and fro so that the burnisher glides over the surface in a straight line, then repeat so that the bright lines touch each other, thus forming a continuous bright surface. For gold or silver, stone tools must be used after the steel ones to get the best effect, but for brass, &c. steel tools will do all that is required and are much cheaper than stone tools. Some shapes of steel burnishers can be used like draw-filing, or the free ene passed under a loop on the bench so that great pressure can be put on the work, the tool being moved by the handle so that it makes a curve, the work under the tool being slowly revolved so as to present fresh surfaces to the burnisher. A tool shaped like a hammer face is useful for large surfaces, or one with a handle at each end and curved at the working part. In any case it must be remembered that *burnishing is producing a series of lines in which the metal has been brought to a very smooth surface by great pressure of a very smooth tool much harder than the work, and kept wetted with the suds of a special soap.* Work required to be dead true must *not* be burnished, and great care taken in preparing the work so that there are no deep scratches, as they are more noticeable on a burnished than on a dull surface. Everything depends on the surface of the burnisher being clean and smooth. To keep it so, it must be from time to time got up by rubbing with pressure on a polisher of good leather mounted on a board and fed with putty powder. Steel burnishers when not in use must be carefully protected from rust.

Although a bloodstone burnisher will last longest, those made of agate stone answer the purpose very well and are much cheaper. For small jobs a bit of agate from an old fashioned brooch can be used, it is easily mounted, and the old brooches can be bought very cheaply.

Re-lacquering old work. Old or spoiled lacquer can be washed off with methylated spirits, or immersed in a bath of caustic soda dissolved in water, for about twelve hours, or wash well with soft

soap and water to remove grease, then boil in strong lye for half-hour (pearl ashes and water answer well), dip at once in cold water and rinse well, the work can then be lacquered as before directed.

Vulcanised indiarubber, or any substance containing sulphur, will rapidly spoil a finished brass surface and even make thin brass quite rotten; this however, can sometimes be turned to advantage. Clean brass and clean rubber soon cement themselves together as in fittings of rubber hose. Gas fittings are so much affected by the sulphur from burned gas that chains of chandaliers, &c., require renewing at times.

Pickle for Iron. A mixture of equal parts of sulphuric acid (vitriol) and water, immerse the casting for two days, the acid will remove the outer skin. **Caution.—The acid must be poured slowly into the water, NOT the water into the acid, as that would cause an explosion.** Acids should be mixed in the open air.

Pickle for Brass may be used instead of burnishing, before lacquering. One part of nitric acid (aqua fortis) to four of water. Dip the work a few seconds, then rinse well with plenty of water and dry without touching the work with the hand. Hot sawdust is excellent for drying purposes, but it must be boxwood or other wood free from resin. Another pickle giving good effects is : one part each—nitric acid, sulphuric acid, and water ; add the sulphuric acid to the water, then the nitric slowly. Lacquer at once after washing and drying.

Ornamenting the surface can be done with designs either raised or depressed. Etching with acid is one of the easiest ways. For an inscription or design raised above the surface, the design should be painted on with a resist or varnish made by dissolving Shellac in Spirits, thin enough to flow from a small brush or even a pen for fine work, or use gas tar thinned with petrol and warm after painting on till dry. The unprotected surface, which must be quite free from grease, is then eaten away with acid. For incised designs cover the surface with a resist of one of the above, or what is easier melt a paraffin candle and coat the surface with it, draw the design with a sharp point and make sure that it scrapes away the wax to leave a clean metal surface, then pour on the acid. It is advisable to build a wall round the edge of the plate with the wax, to prevent the acid flowing over the edges. For brass or iron use nitric acid, for zinc or aluminium use muriatic acid. When etched deep enough wash off all trace of the acid and scrape off the resist.

Sand Blast, for either cleaning or ornamenting the surface of metal, can be made by allowing sharp sand to fall on the work through a tube so as to get as much fall as possible, at least ten feet, the effect is best with the greatest fall. The work must be slanting so that the sand, after striking the surface, will at once fall off it. If a steam jet can be used, the blast can be easily arranged something after the style of a blow-pipe, the supply of sand falling through a tube attached to the nipple and surrounding the steam jet. Any parts protected by paper glued on will resist the sand long enongh for the remainder to be roughened. Glass may be treated the same way. The paper is more effective if coated with copal varnish.

COLOR DIPS FOR BRASS.

Orange.—Dissolve Acetate of Copper in water, add potash till the solution is neutral, dip the work a few seconds, then rinse with clean water and dry. **Green.**—Sulphate of Copper dissolved in water; dip the work till the required color. Nitrate of Copper gives a better effect; make a strong solution and boil the work a few minutes in it. **Gold.**—A strong solution of Oxalic Acid gives a good shade. **Violet.**—A hot solution of Chloride of Antimony; heat the metal and dip. **Moire.**—A pretty effect is got by boiling the brass for some minutes in a strong solution of Sulphate of Copper to which a few drops of Sulphuric Acid are added, say half-ounce acid to two pints. **Antique Green.**—Effects like ancient bronze. Dip in dilute Acetic Acid, then expose to the fumes of Ammonia; repeat this process as required. **Steel Grey.**—Make a weak solution of Chloride of Arsenic, and boil the work a few seconds. **Copper** color on **ZINC** or **IRON** is produced by making the work quite free from grease, and dipping in a strong solution of Sulphate of Copper. **Gold** color on **TIN** or **WHITE METAL** can be got by the following lacquer:—1-lb. Shellac, ¼-oz. Tumeric, 4-oz. Dragon's Blood, with enough spirits to make a thin lacquer. The work must be heated. The proportions of coloring matter vary with the shade required. An easier method is to color a clear lacquer with yellow analine dye. Any color can be had this way but it is not as permanent as the other recipes given above.

Bronze Color on Brass is produced by boiling in water in which sulphate of copper, alum, and verdigris have been dissolved. The work may be left dull or lacquered.

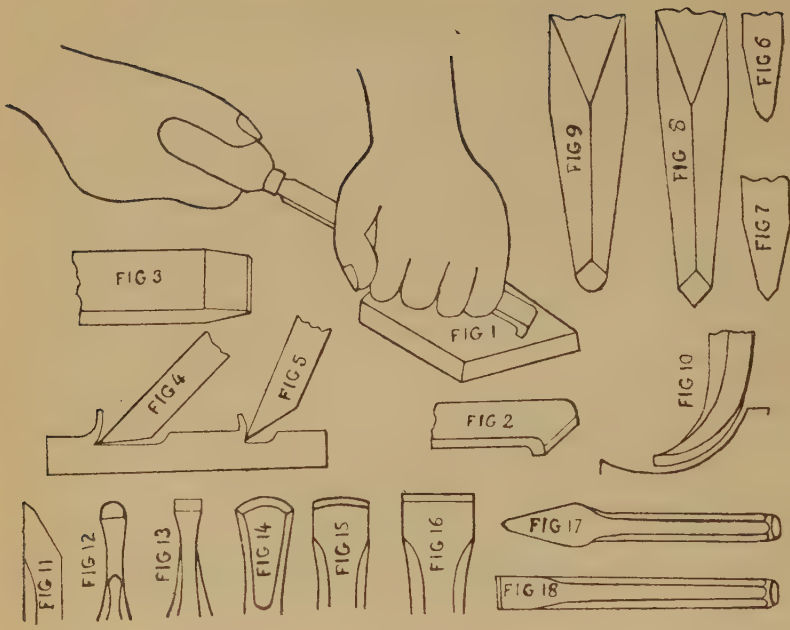
Lye for removing Old Lacquer. Half-pound potash to one gallon of water, boil the work twenty minutes. Two or three minutes in this will remove grease from work.

One of the best colorless lacquers is collodion, this must be kept away from any flame whilst applying as it is highly inflammable. It is very suitable for silver or plated goods.

Vaseline is a safe and easily applied protection for both brass and iron surfaces, protecting the latter from rust. Thin rubber solution may also be used for iron.

Making Lacquer. This should be bought ready made, It can be had in many shades, from quite clear for silver, to deep gold color for brass. To make pale gold color: dissolve 1-oz. seed lac in 16-oz. methylated spirits, add a little each of Tumeric, Gamboge and Saffron. If for deeper color, add also a little dragon's blood. The proportion of coloring matter depends on the tint desired and the color of the metal, tin may be lacquered to resemble deep gold colored brass.

Colorless Lacquer. Bleached lac dissolved in methylated spirits.



Explanation of Diagrams.

Fig. 1—Shows Scraper in use, the work being done in pushing the scraper, which is held in the right hand, pressure being put on it with the left,

Fig. 2—Enlarged View of End of Scraper.

Fig. 3—Ordinary Shape of Scraper made from a File.

Fig. 4—Shows angle at which a Chisel will cut.

Fig. 5—Bad angle. the chisel sinks into the work instead of cutting.

Fig. 6—Chisel has been ground at cutting edge only until it is round ended.

Fig. 7—Correct Shape of Chisel End.

Fig. 8—Diamond Pointed Chisel of square section at top end.

Fig. 9—Round do. do. do.

Fig. 10—Curved Chisel for cutting round inside of curved surface.

Fig. 11—And those shown as 4 and 5 are easy to make as they can be shaped on grindstone from bar steel without forging.

Fig. 12—Round Nosed Chisel for cutting deep groove or slot.

Fig. 13—Flat do. do. do.

Fig. 14—Round Ended Chisel suitable for small curved slot.

Fig. 15—Curved do. one of the most useful shapes.

Fig. 16—Square do. the shape in most general use.

Fig 17—Usual shape of Narrow Slotting Chisel made from octagon steel.

Fig. 18—The Ordinary Chipping Chisel made from octagon steel.

COPYRIGHT

Tinplate Working with Hand Tools.

By M. COLE.

* * * * *

There are few manufacturing processes in which there has been greater progress made in the introduction of machinery than Tinplate Working, and probably none in which so much can be done with the simplest tools. The instructions given below are intended to show how to work with the smallest number of tools, and those of the cheapest and simplest kinds. The instructions apply also to working in other sheet metals of the same thickness.

THE MATERIALS. **Tinplate** is sheet steel, coated both sides with tin, it is very ductile, and spreads well under the hammer though not so well as sheet copper. **Zinc** is less easy to work, and rather difficult to solder, does not bear rivetting well, being apt to tear at the holes. **Solder** is an alloy, usually a mixture of lead and tin, but for special purposes other metals are sometimes added, causing it to flow at a lower heat. **Brazing Spelter** is a form of brass, melting at a much lower heat than ordinary brass, and is used for seams in copper, &c., when required to stand greater heat than tinman's solder would bear; when this is used a gas blow-pipe or other means of producing great heat is required, while ordinary solder can be used with a copper-bit. **Soldering Flux** for tinplate is usually either common **Resin** or **Soldering Fluid** also known as **Spirits**, of which there are many special makes, much superior to the old spirits, which consist of "Spirits of Salt" or "Muriatic Acid" in which bits of zinc have been dissolved, until the acid will not take up any more. The drawback to this spirit is that it is corrosive, and if not well cleaned off is apt to rot the seam. The fluid is applied with a small brush to the seam. If resin is used it must be powdered first.

TOOLS REQUIRED.

Anvil. This need only be a piece of iron with a flat surface. For small work an ordinary laundry iron, of which the handle has been broken off, does very well if bedded down on a block of wood so as to get a solid bearing, or a complete laundry iron can be used, the handle being fitted into a heavy block of wood. For large work a heavier iron block will be required.

Block. A wood block is required for hollowed work. This is usually the butt or lower end of a tree, and should be as heavy as can conveniently be got. The top surface has hollows of various depths and sizes in it, in which the work is hammered with a round faced hammer.

Rivetting Set. This is a punch having a hole in it a little larger than the rivet to be used, and also a shallow hollow used to give a finish to the head of the rivet when rivetting down, a short length of iron pipe will do if of the correct bore.

Mallet for tinplate work is of soft wood not too heavy to handle with ease. For heavy sheet iron it should be of hard wood and hooped with iron to prevent splitting.

Shears and Snips. For thin metal small snips will do all that is required: for heavier sheet metal, as used for stove pipes, &c., the larger shears are better.

Stakes. One or more of these will be required to suit various operations, but for small work a hatchet shaped, and a small round one will do a great variety of work.

Soldering Bolts. Otherwise known as "Soldering Irons" or "Copper Bits." A pair of these should be bought; the heavier they are, the longer they will remain hot, but for odd jobs a single one will do. In any case do not buy one less than 12 ounces weight.

Hollowing Hammer. When hollowing work has to be done one of these is absolutely necessary. They are not very expensive and do a large range of work. The two faces are rounded to different curves, and should be worked on the portion of the block having a hollow similar to the curve of the hammer face.

Marking Out. The work is marked out on the sheet tin with any pointed tool to the shape required, as explained in the diagrams. For difficult shapes it is as well to try the shape by cutting out of stiff brown paper to see if the design is correct before cutting up the tin.

Cutting Out the Work. This is done with the shears or snips according to the thickness of the metal. If very thick it may have to be cut with a chisel, though this is seldom necessary. The ordinary snips can be used to cut any length and almost any curve. They are used in similar manner to ordinary scissors, but as the metal is not as flexible as cloth, &c., it is necessary to see that the piece cut off is bent sufficiently to clear the hand holding the snips, or it will cut the fingers or the back of the hand. It is necessary also to be careful that the snips do not move sideways, which they are very apt to do if not held in such position that the flat of the blade is at right angle to the metal being cut. The large shears are used in the same way, but are either fixed to the bench by one of the handles or gripped in a vice. In using the snips be careful that at the end of the cut, when the resistance is removed, they do not close suddenly and catch the side of the hand between the ends of the handle. This will probably happen however careful the user is at first, but it seldom happens a second time; the result, though painful, is not serious. The smaller snips will cut any metal in ordinary use, but the larger ones cut more easily and quickly. When the metal is thick, it is sometimes an advantage to grip one of the handles in a vice, and work the other one only. For cutting very small curves, a pair of snips with curved blades are very useful, but it is quite possible to cut almost any curve with the ordinary ones.

Bending. When working with hand tools only, the bending of the edge is done with mallet on the edge of the stake, as shown in the diagrams; the bending is done a little at the time, going over the edge three times in bending to a right angle. A line should be drawn on the work as a guide, or the bend is apt to be uneven. The hatchet stake can be used to bend any length of straight, the curved stake can be used for any curve so long as it is not smaller than the

curve of the stake. When a large curved surface is required it can easily be bent over a wooden roller, for smaller ones the tin may be partly lapped round the roller and then unlapped to a larger curve. Lay the tin and roller on the bench, then gripping the tin and roller together pressing on the bench, roll the two, then move the roller a little further and repeat.

Seaming is shown and fully illustrated in the diagrams, the edges being bent over the stake and put together as shown, they can then be closed up with the mallet, and if necessary soldered down the seam.

Wiring. Wires are inserted to strengthen the edges. Proceed to bend as directed and insert the wires as shown in the diagrams.

Soldering is usually done with the copper-bit or soldering bolt. The parts to be joined are (unless using new tinplate) cleaned by scraping where the solder has to stick or it will not make a joint. Rust in particular must be removed, and all traces of Paraffin Oil. A flux is required. For tinplate it may be either resin or Soldering Fluid. The bit is heated nearly *but not quite* red heat. If too hot the coat of solder on the working face will be burned into the copper forming a film of bronze, while if not hot enough it will not melt the solder and heat the parts to be joined. If two pieces of metal are to be soldered together, the solder will not stick until the *metal is hot enough* to enable the solder to alloy itself with the metals to be joined. With a new Soldering bolt, or one of which the face has been burned, it is necessary to file the working end quite bright, then heat sufficiently, give another touch of the file, and then proceed to tin it by rubbing on a bit of sheet tin (some use a stone) on which is some solder and the flux used; it will take up some of the solder, and when applied to a job and slid along a seam, part of the solder will leave the bit and adhere to the tin at the seam. The place to be soldered having previously had a supply of the flux. A further supply of solder being taken up as required. When soldering the edges of a loose piece of tin, it is necessary to hold it down until the solder has set; any bit of metal or stick will do for this. If a long seam, it is usual to put a bit of solder at intervals to hold it in place before running the bit down the length of the seam. The larger the bolt, the longer it will keep hot. It is best to have two in use, the one heating while the other is being used. The usual way of testing if a bolt is hot enough is to hold it about three inches from the face. If hot enough to use, the heat is very perceptible; if it is too cold, no heat will be noticed at that distance. When fluid is used, the joint should be well washed and wiped dry. If resin is the flux, the surplus can be scraped off. In soldering Zinc, the flux used should be Hydrochloric Acid, known also as Spirits of Salt. It should be used just as bought. Zinc, however, is not an easy metal to solder, as it is apt to strip the tinning off the soldering bolt.

Rivetting. When extra strength is required, and also in metals that do not take solder well, the seams are often rivetted together. The metal being thin, punching the hole is not difficult. The easiest method is that shown in the diagrams, where a rivet is placed under the two thicknesses of metal, and a bit of hard wood on top. A smart blow with the hammer will drive the rivet through, if the

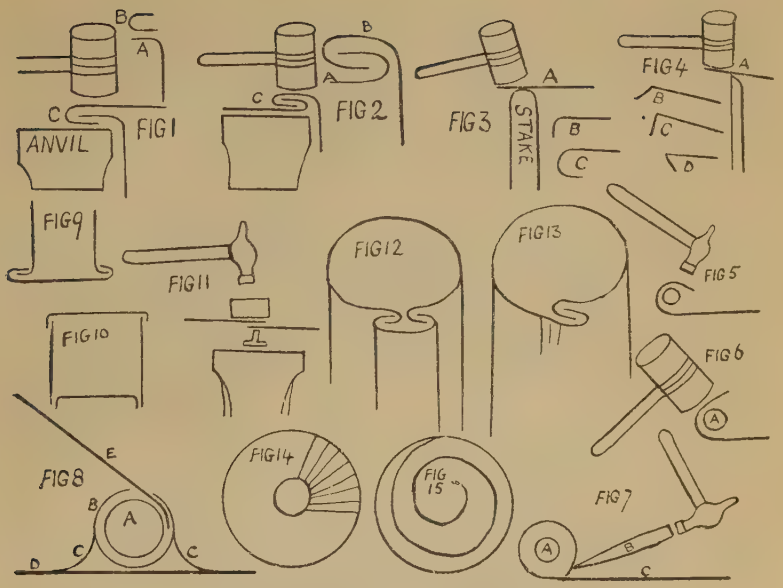
metal is thin. If too thick for that it will at least make a deep dent in it. If again placed in position, and the hole of the riveting set placed over it, a smart blow of the hammer will send it through, and the projecting end can be riveted down, being careful that the two thicknesses of metal are held down during the process, otherwise the rivet may spread between them and hold them apart, instead of forcing them together. The hollow in the riveting set is then used to give a finish to the rivet head. The rivets are of soft iron, for the smaller sizes washers are not required, but for larger work or where there is a great strain it is advisable to use them. The rivet should be a tight fit. If too small for the hole it will not close properly (unless a washer is used), and the part projecting must not be longer than is required to form the head. If too long it will probably be forced sideways.

Hollowing. If a piece of sheet metal be laid on a hard surface and struck with a hammer, the result is a depression or bulge. No amount of hammering in the bulged place will bring it flat again; on the contrary, the more it is hammered the more the bulged part expands, the metal having become thinner, and as it is prevented by the surrounding parts from expanding at its circumference, it has to expand by becoming part of a globe or such other shape as the hammering inclines it to; and by skilful use of the hammer a vast variety of shapes can be produced. The hammering is done on a block as described, a hollow being chosen suitable to the work, a shallow one to commence, followed by a deeper one if necessary, but at all times carefully avoiding the use of a hollow of smaller curve than the finished work is to be. The hollowing should start at the edge of the work, but the part where the greatest amount of stretching is required, must receive the greatest number of blows. A strip at the extreme edge is left untouched by the hammer to keep the work to its original size except where a flip is required. It is not necessary to work each plate separately, in fact better work is done by hammering 3 or 4 at the time. Hollowing being the most difficult part of the work, it is advisable to learn on a piece of sheet lead, using a wooden mallet having a rounded face. This is a much easier method than starting with tinplate.

Polishing. After the work is finished, it must be thoroughly cleaned, especially the seams. All resin scraped off, all seams on which fluid has been used well washed and dried. The work can then be polished up with dry whiting applied with a rag and plenty of friction.

Lacquering is very effective. Tinplate can be made to look like polished brass by a coat of Coloured Tin Lacquer, which is also useful for seams in brass that have been soldered, bringing the solder up to the colour of the brass.

Galvanized Sheet Metal. A good deal of this is in use for work for which ordinary tinplate is too light. It is coated with zinc instead of tin, and is soldered (when required) with Spirits of Salt as flux, but as it is usually for outside work soldering is seldom required. There is also the low quality plate coated with lead, or a mixture of lead and tin, to save part of the cost of the tin. This is mostly used for packing case linings.



SEAMING AND WIRING.

Fig. 1—Single lap joint. A and B show how the edges are bent over. C how put together and closed down.

Fig. 2—Details of double lapped joint.

Fig. 3—Bending edge round top of stake to prepare for wiring, &c. A, B, and C showing successive stages.

Fig. 4—Details of flat bend over on sharp edge of stake.

Figs. 5, 6, and 7—Wiring edge with hammer or mallet, and finishing with drift or dull chisel.

Fig. 8—Simple tool for bending edge of sheet. A is a rod fitting loosely into B a split tube, which is fastened to a base as shown, on turning A by a handle at its end the tin is carried round with A, and can be removed by pulling out at the end.

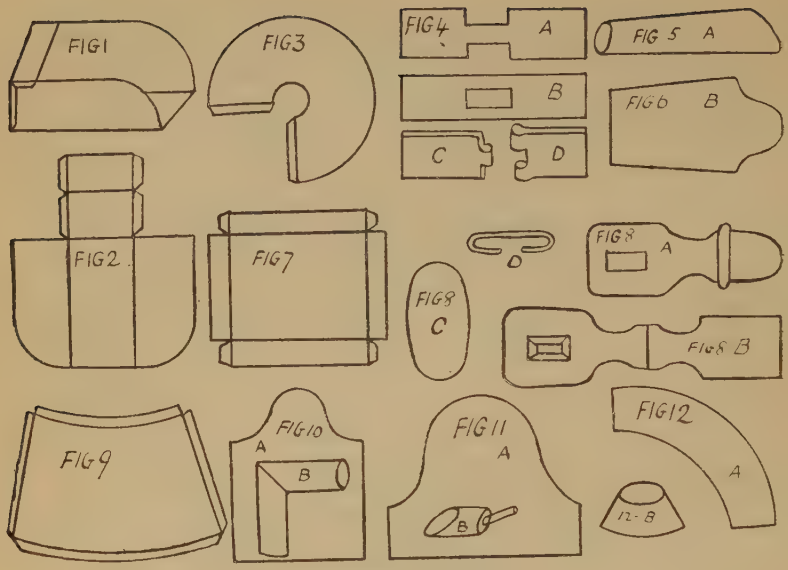
Figs. 9 and 10—Various methods of bottoming cans, &c.

Fig. 11—Rivetting. The two thicknesses of sheet metal are laid on the rivet, which rests on the anvil. When the bit of wood on top is struck a smart blow with the hammer, the rivet will penetrate the two thicknesses of metal.

Figs. 12 and 13—Two methods of joining stove piping.

Fig. 14—A makeshift method of cutting a round hole in sheet metal by a series of cuts ending at the large circle.

Fig. 15—A much better way. Commencing near the centre, cut a spiral roughly until the edge of the circle is reached, then cut carefully along the mark: the centre part having been removed by the spiral cut renders this easy.



MARKING OUT.

Fig. 1—Square scoop, the handle is not shown.

Fig. 2—Pattern for the square scoop. The lines show where the metal is bent to shape, the narrow pieces lapping over to make a stronger joint.

Fig. 3—Pattern for funnel, and other conical shapes. The one shown has one quarter of the circle removed, but the shape can be varied by cutting away more or less.

Fig. 4—Sheet metal hinges. A and B showing how to cut out. C and D the shape after bending. They are united by a bit of wire.

Figs. 5 and 6—A Teapot Spout. B the shape it should be cut.

Fig. 7—Pattern for a shallow pan.

Fig. 8—Details of sheet metal hinged clasp for padlock. A showing the finished clasp. B shape to cut. C bit to form hinge with wire D.

Fig. 9—Pattern for tapering coffee-pot body.

Fig. 10—Stove pipe elbow. A showing shapes in the flat.

Fig. 11—Round scoop.

Fig. 12—Pattern for a tapered can.

RE-TINNING KETTLES, &c. Iron and copper pans, &c. have a thin layer of tin to prevent rusting or copper poisoning. This is worn off in use. To re-tin, clean the surface with sand, or if necessary emery cloth until quite bright, wet well with soldering fluid and put in some tin (*real tin, not solder*). Apply heat until the tin melts, then spread it all over with a mop or rag at end of a stick.

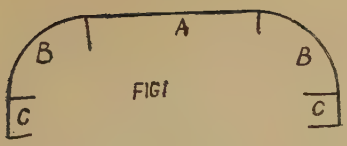


FIG 1

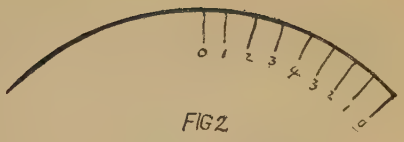


FIG 2

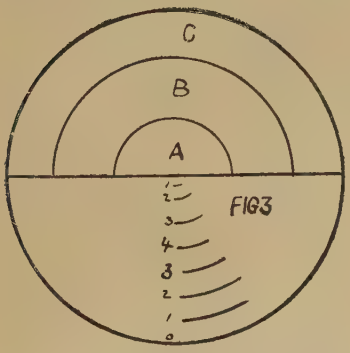


FIG 3

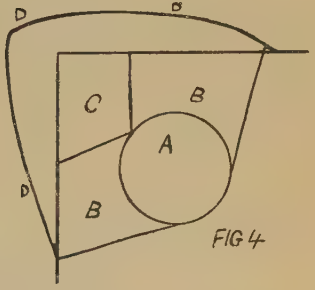


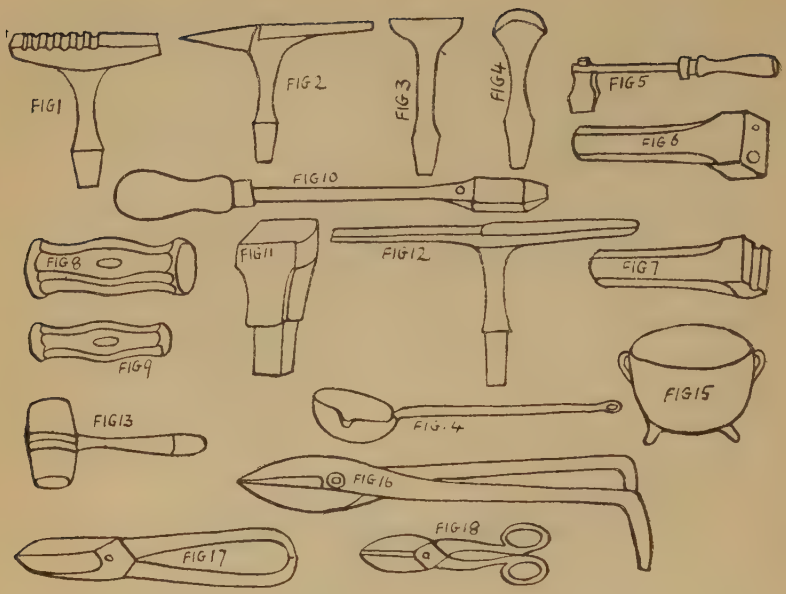
FIG 4

HOLLOWING SHEET METAL.

Fig. 1—Shows section of a basin having flat bottom A, and straight sides C, the hollowing being at B, see also the upper part of fig. 3 The part A is untouched by the hammer. Most of the work is in the strip B, the part C requiring very little, and that at the part nearest to B, gradually decreasing as it nears the outer edge which is not touched by the hammer.

Fig. 2—Shows a much easier curve to hollow. In this case the whole surface is hammered except the extreme edge, and the exact centre, both marked o (see also lower half of fig. 3). The hammering is graduated according to the figures on the diagram. The hollowing would start at 4, working round in a circle at the same distance from the edge, and going lightly the first round, next follow three rows of hammering at 3-4-3, then round again at 2-3-4-3-2, then again going over the work at 1-2-3-4-3-2-1. The first few rounds will show the marks of the hammer, but as these marks overlap each other, the frequent crossings obliterate the hammer marks and reduce the whole to a good surface. After some practice in working in this manner with light blows, it will be found easy to do the work with a smaller number of rounds, giving more force to the blows of the hammer, and three or more plates can be hollowed at the same time.

Fig. 4—Shows what may be called the *Science of Hollowing*. A being a bulge near the corner of a square of sheet metal produced by one or more blows of a round-faced hammer. BB show the parts where most of the hammering would be done, very little being required at C, and the line DDD shows the shape the corner would be by the time the bulged part has been flattened.



TOOLS FOR SHEET METAL WORKING.

1. Creasing Iron. The square end is used as a Beak Iron, the grooves are of various sizes of wired edges of work.
2. Beak Iron, one side has tapering horn for round work.
3. Stake, hatchet shape for straight work.
4. Stake, half-moon shape for curved work.
5. Copper-bit, plumbers' shape but useful for tin work.
6. Rivetting Set, with hole, also counter-sink for heading rivets.
7. Groove Punch for wired edges.
8. Planishing Hammer, flat faces.
9. Hollowing Hammer, round faced, various sizes.
10. Copper-bit, usual shape for tinplate working.
11. Anvil for inserting in bench, one side rounded.
12. Beak Iron for long work.
13. Wood Mallet—soft for tinplate, hard for sheet iron.
14. Hand Ladle for melting solder in small quantities.
15. Cast Iron Pot for melting solder in large quantities.
16. Stock Shears for heavy sheet metal, the bend at end of one handle is inserted in a hole in bench.
17. Snips for cutting small work. This shape is easier to use than fig. 18, the handles being grasped by the whole hand instead of fingers and thumb. These can be had with curved blades.
18. Scotch Shears.

The Anvil, Stakes, and Beak Irons are inserted in holes made in the bench. As they soon work loose it is usual to pour some melted lead between the iron and the wood to ensure a good fit.

COPYRIGHT.

Wiped Joints in Lead Water Pipes, Soldered Joints in Lead Gas Pipes, Lead Burning, &c.

By M. COLE.

* * * * *

In jointing Lead Water Pipes, they are first fitted together by tapering one end, opening out the other end to make a socket for it. Part of the solder is shaped to a bulb surrounding the joint, thus making it doubly secure. The following is the method of working :

1—Drain the pipes free from water. 2—Shape the ends so that they fit well together. 3—Soil the parts where the solder is not to stick. 4—Fix the parts so that they do not move. 5—Melt the metal. 6—Pour over the joint to heat it. 7—Wipe to shape. 8—Trim off with hot iron if necessary.

Drain the Pipes. The pipes must be quite dry and so arranged that no water can come down them during the process of making the joint, or it will be vapourised by the heat and blow through. One way of making sure of this is to plug the pipe above the joint with some bread worked between the hands till like putty. The water when afterwards turned on will soften this and carry it through the pipes. Sometimes a small hole is made in the underside of a bend (to drain it) with a pointed nail. This is easily closed again after the joint has been made, by dressing the lead up to it.

Fit the Ends together. The ends must be shaped to fit together very exactly. This is very important, as the solder will run to the inside of the pipe if there is any opening large enough to allow it to do so. If well fitted, the solder is sucked between the surfaces and binds the parts together, making a joint as strong as any other part of the pipe, even without the metal forming the bulb, which seems to have been originally introduced to cover bad work. The surfaces in contact should be at least ¾-inch, and more for large pipes. The taper end is trimmed to shape with a rasp, and it is necessary to be able to use it in either hand, left or right. It is better to spend a little extra time on this part of the job, than in making a nicely shaped bulb. The cup into which the taper end fits is made with a tool of hardwood called a turnpin. This is a very simple matter as it has only to be hammered in to the bore of

the pipe till the lead spreads to the shape required. A little tallow helps this. The pipe is grasped with the left hand near the end, at the same time holding the turnpin in position while struck by the hammer held in the right hand. A special tool is made for preparing the joints of lead pipes. It is very similar to a pencil sharpener on a large scale, and it makes the ends of both pipes the same angle of bevel, thus making a good joint. The use of this tool has the further advantage that it prevents any shavings of lead being left in the pipe, as is often the case when the ends are trimmed with a knife.

Scrape the parts to be soldered. This should be done with a shaving hook, although a knife will do the work. As soon as a bright surface is got, it should be at once greased with tallow, to prevent even the thinnest film of oxide forming on it. Some workers use chalk or whiting in place of tallow. As tallow is not always procurable, butter or margarine (which is no dearer than tallow) will be found to answer quite as well and can always be had.

Soil beyond the joint. This is done only for the sake of appearance, and does not in any way improve the joint. The soiling is painted on with a stiff brush, an old sash tool does very well for this. A bit of paper may be lapped round the pipe so as to get a nice edge to it. Lampblack and thin glue water make a good soiling which softens when wetted and dries quickly. Ordinary boot blacking will do when the right stuff cannot be had.

Fix the parts in position. How this is done depends on the position of the pipes, and whether new work or repairs. The pipe vice is very handy for this purpose, and is a great saving of time. In any case give as much room as possible to work round the pipe. The mode of using this is shown further on, but whatever method is adopted the pipes must be fixed so firmly that they do not move during the time the joint is being made. A few bits of timber and nails, and a little ingenuity, will enable anyone to fix the pipes so that they will be rigid.

Melt the metal. This is done in a metal pot as shown in the diagram, but for an odd job, the large sized ladle will do. The metal should be hot enough to brown a bit of newspaper thrown on it, but not to set fire to the paper. If the metal is made too hot, the tin is liable to be burned out of it, shown by grey dross on the surface. As soon as the metal changes color it is too hot. The quantity must also be enough for the job, as a good deal has to be poured over the joint to heat it, before any is used to form the bulb. Another reason is that a small quantity is liable to cool down before the job is finished. This matter does not always get the attention it deserves. Many a pot of good solder is spoiled by the tin being burned to a dross, and the plumbers grumble afterwards about the bad quality of the solder when making the joints. It is usually the fault of the "mate," and it is one of the first things an apprentice should be taught. To keep the air out put some tallow on the surface, or a layer of flour which is soon burned to charcoal.

Pour the metal over the joint to heat it. This is a very important part of the work. Solder will not stick to the lead unless the lead is hot enough to allow the solder to combine and form an

alloy with the surface lead. The metal must be poured from the ladle over all the part that is to form the bulb and allowed to run off it until the pipe is hot enough. Some brown paper or a board can be put under the job to catch the solder and keep it clean for melting again. So that when starting a job, it is necessary to see that there is enough solder to warm the pipe as well as to make the joint.

Wipe the joint to shape. When the pipe is hot enough, some of the metal (now much cooler than at the beginning of the job) is lifted with the cloth and stuck on the joint. The cloth is held under the joint with the left hand, and the metal poured from the ladle with the right hand upon the joint, all that overflows is caught on the cloth and pressed upwards, then shaped or moulded round the joint adding more metal until the joint is large enough. It is in this state as soft as putty, and is easily shaped as required to make a bulb of the desired shape. A looking-glass is used to enable the worker to see that the back or underside of the joint is properly made.

Trim off with hot iron. This is not necessary when the worker has skill enough to shape a bulb at once, unless a very large one. Make the iron red-hot, and with it soften the bulb where required, then wipe to shape. The iron is however, seldom used now. A plumber is supposed to be skilful enough to wipe to shape with a cloth except in case of extra large pipes.

Splash Stick is used to splash the metal on, in places where it cannot be poured from the ladle. With a little practice it will be found easy to jerk a little at a time of the metal to the required spot. The stick is usually about 8 inches long—1½ in. wide, ½ in. thick, but there are very few joints that cannot be got at with the smallest of the ladles.

Jointing with Torch. All Corporations and Water Companies specify "Wiped Joints," but these can be made with a torch such as in general use by plumbers. In this case after preparing the joint as directed, allow the flame to play on the joint and a few inches each side, until hot enough to take the solder. For this job it is used in sticks and dabbed on a bit at a time, as it softens with the heat of the flame, and wiped to shape. In the ½ in. water pipe used in dwelling houses, a wiped joint can be made even with the pocket spirit torch used by most plumbers, but with the "*Swedish Torch*" a joint can be made in any size of lead pipe, large or small.

Branching off Main Pipe. This is done in a very similar manner to the end to end joint. The branch pipe is tapered at the end, and a hole bored with a gimlet in the main pipe. This is gradually enlarged with any round tool that will enter it, tapping it with a hammer on the edge of the tool till the lead is dressed to cup shape, and cleaned up as described. See that the end does not enter too deeply into the cup, or it will interfere with the flow of water.

Tap on end of pipe. The tap must be well tinned first. Clean the part that has to take the solder quite clean and bright, using a file if necessary; then with copper-bit and soldering fluid give a good coat of fine solder, and proceed as for any other wiped joint. Most taps are now fitted as branches instead of being inserted in the end of pipe, though that is the easier way.

Mending Frost Bursts. When a pipe is burst by the frost, it is because the water contained in that part being frozen solid, occupies a larger space than when in a fluid state. The lead being brittle at freezing temperature, breaks instead of stretching as it would at ordinary heat, but as the pipes are usually repaired when they are warmer and more ductile, it is easier to dress it back to the original shape. Gently tapping with a light hammer will bring the parts back to their proper position again, and in many cases it need not be soldered for some time after, if other jobs are pressing.

Cleaning Solder. Plumbers coarse solder is usually two or three parts of lead and one of tin. It sometimes gets overheated and the tin is oxydised or burned. In this case more must be added. At other times by some means zinc gets into the metal making it useless for joints. To remove this, heat to near redness, drop in some stick sulphur, and stir up. The sulphur will bring the zinc and dross to the surface when it can be skimmed off.

SOLDERED JOINTS IN LEAD GAS PIPES.

With Copper Bit. One end of the pipes to be joined is opened out with the turnpin, the other end scraped down taper for about ½-in., so as to fit well into the cup formed by the other end, and not to allow any solder to flow down to the inside of the pipe; both parts are scraped quite bright and greased with tallow then placed in position and fastened so that they do not move during the soldering. A little more tallow is now placed in the cup which is not quite filled by the taper end, but forms a small ledge to hold the solder. Some powdered resin is now placed in this, which the tallow will hold in position. The copper-bit being now heated, touch the edge of it with a stick of fine solder and the copper-bit will take some of it up. On placing the end of the bit to the joint, it will part with some of the solder which will remain in the cup. If the stick of solder is held in the left hand and the copper-bit in the right, the solder is easily and quickly applied. Moving the copper-bit so that the edge travels round the pipe, the solder following it, and a sufficient quantity of it remaining in the cup. The heat of the copper-bit warms the pipe sufficiently to enable the lead to take the solder, and a portion of it flows into the joint between the surfaces. A carefully made joint of this description is quite as strong as any part of the pipe it joins, and is really good enough for water pipes, though against the regulations of Water Companies and Corporations.

Tinning the Copper-Bit. To do good work it is necessary that the copper-bit should be well tinned, or coated with solder on the working edge. If heated too hot, the tin in the solder is burned into the copper and it refuses to take up solder. It must now be heated nearly but not quite to redness, the edge to be tinned must be filed bright and at once rubbed on a bit of tin on which is some resin, or soldering fluid, and some of the solder to be used. The solder will now adhere to the newly cleaned surface, and a good deal can be carried by it to the joint, where some of it will leave the copper-bit and stick to the lead.

Jointing with Gas Blow-pipe or Torch. When this is done, prepare the joint as directed, and blow the flame on the parts, care

being used not to over-heat them. This is a very clean and quick method of working, gas of course being the most convenient. Fine solder must be used for these joints, with either copper-bit or blow-pipe, it melts at a much lower heat than the coarse solder used for wiped joints. It should consist of equal parts of lead and tin. As tin is so expensive, low priced solder should be carefully tested before buying, as it seldom contains as much tin as it is supposed to have. For blow-pipes the very thin stick should be used, the end of the stick is placed against the joint, and the flame melts it. For this purpose it is worth while to use a finer quality of solder made of three of tin to one of lead.

Gas Fitter's Torch. The Swedish Torch gives too much heat for the smaller gas joints. The old form of torch, burning Methylated Spirits, is used for this, and is easily made out of $1\frac{1}{2}$ in. or 2 in. brass tube, and must have a cap to prevent evaporation when not in use. The air tube is a bit of "*Twigging*" bent at the end, which is easily done with the fingers, and a bit of much thinner tube inserted in the end. For the latter, part of a small brass hinge will do well. When spirits cannot be had, there is still the old method of a tallow candle and mouth blow-pipe, which is quite as quick for small jobs.

Cutting Lead Pipes. The thin pipes used for gas are easily cut with a pocket knife if the pressure is carefully applied. The blade must be carried round the pipe, the thumb being at the other side so as to get the necessary pressure. Water pipes are too thick to be cut this way, and a small saw, usually a joiner's keyhole saw is used for the purpose. Another way is with a hack knife and hammer, but this method always causes the pipe to go out of shape, and gives a lot of extra trouble afterwards in working it to round section again.

Compo. Pipe is sometimes used for light weight gas pipes. This is harder than the lead pipes, and does not flatten so readily, but is not so easy to work as pure lead in opening the ends for jointing.

Rubber Gas Tube should be used as little as possible, as it is rapidly attacked by the hydro-carbons present in the gas, and soon impregnated with them to such an extent as to give off a very unpleasant smell which cannot be remedied. Many modifications of rubber tubing have been invented to avoid this, but none of them are really successful. All gas stoves, &c., unless of the very smallest size, should be fitted with metal supply pipes. When ordinary lead pipe cannot be used, the flexible metal tubing with screwed brass ends should be fitted. These should be soldered on, though usually they are only fitted with white lead. Rubber ends should never be used with the metal tubes.

The Copper-Bit should be as large as can be conveniently used. If the source of heat is quite close, the smallest size will do for gas joints, but if at a distance the tool is apt to cool down before it can be got to the job, and nothing is more annoying than to have to heat the bit two or three times to make a gas joint.

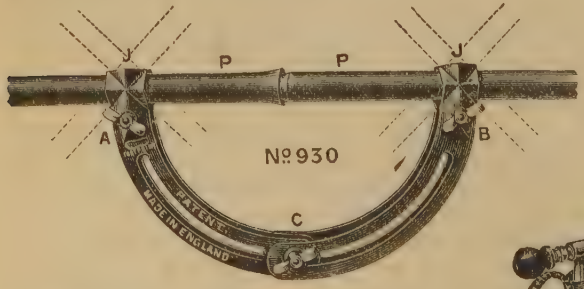
The Cloth is Moleskin, as used for workmen's trousers, &c., and old is better for the purpose than new. For a beginner it should be three thicknesses, and about six by five ins. After some practice a cloth about half the size will be large enough, at any rate for joints of ordinary size. It should have plenty of tallow soaked into it.

The Solder. Coarse solder is best made as required from old lead pipes, adding the tin purchased for the purpose. Fine solder should be bought ready made in sticks. The lead must always be melted first, then the tin, broken small, is added and at once pushed below the surface. If the tin is melted alone, most of it will be oxydised to a grey powder which requires a great heat to melt it again. The drums inside wet gas meters are composed of pure tin, and old ones can be bought very cheaply.

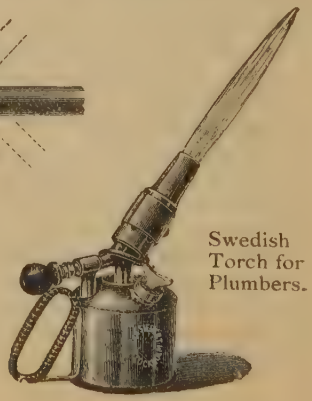
Ladles. A pair of ladles, one each of largest and smallest sizes will do for wiped joints for occasional use ; the larger one to melt the metal, the smaller for pouring with. When for regular use a metal pot should be provided.

An easy method of Testing Gas Pipes and Fittings. Turn off at meter, also all taps, &c., on fittings ; remove the burner of a bracket, turn on and blow down it, getting as much pressure of air in it as possible, and before removing the mouth turn off the tap. Allow to remain under pressure one minute, then turn on the tap. If the air blown down is still under pressure, the joints are good. If the pipes hold pressure for half a minute, they are quite up to the average of gas fittings.

Laying New Piping, either for gas or water, it is necessary that drainage should be considered. Water pipes should be so laid that after turning off the stop tap all water in the rest of the pipe can be drawn off by another tap placed near it, a tap at the highest part of the pipe being turned on to allow the air to enter, so as to prevent the freezing of pipes in severe weather. Water supply to business premises should always be so fitted. When laying gas pipes it should be remembered that some moisture comes over with the gas and remains in the pipes. Although very small in quantity, it accumulates, flowing to lowest part to which it has access, and a very small drop is enough to stop the gas supply. A lesser quantity will cause the gas flame to jump. It can be remedied for the time by blowing down the pipe so as to displace the drop of water, but in properly laid pipes there will be provision made to enable the water to drain down to the lowest part of the pipes, where it can be drawn off by a tap placed for the purpose. A cycle pump can be easily adapted to use for this purpose. Pipes should always be laid with a fall, never horizontally.



Patent Pipe Clamp.—This can be adjusted so as to hold pipes up to 1 in. in any position and at any angle. It is light and portable.



Swedish Torch for Plumbers.

LEAD BURNING or AUTOGENOUS SOLDERING.

This is a method of joining the edges of sheet lead without the use of a solder or alloy that melts at a lower heat than the lead. The usual object is to avoid a joint containing tin which is acted on by acids (as Sulphuric acid) which do not corrode lead, or do so very slowly. It is also used for jointing sheets of lead on roofs where a large surface is exposed. As the lead is subjected to a great range of changes of temperature, and therefore of alternate expansion and contraction, it is found that the alloy soldered joints do not expand and contract equally with the lead, and gradually the parts joined become brittle and break. In manufacturing towns the rain after a spell of fine weather is very acid, and attacks the tin in the solder if used. The sheet lead having been dressed down in position, and the edges pared and scraped clean and accurately fitted to touch without any gaps, but also leaving a V shaped groove. Smear the bright surface with tallow and dust on powdered resin. A strip of lead is then scraped clean and placed on the joint and the flame of a powerful torch directed on it until the strip melts and joins the edges of the sheet lead below it.

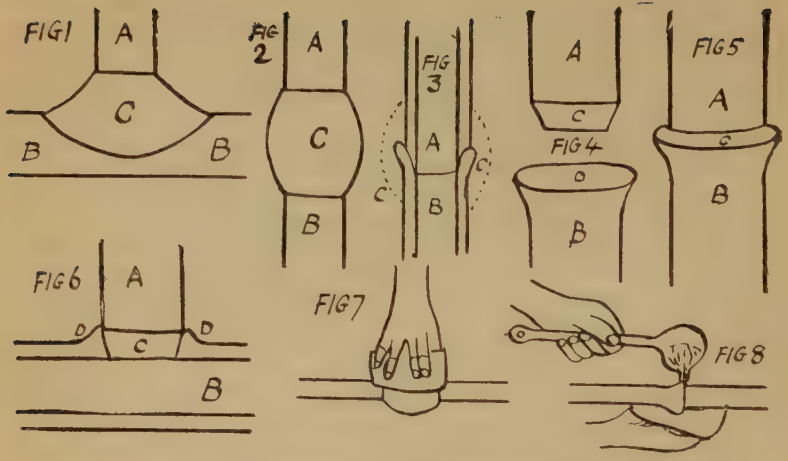
For large work the special lead Burning Machine has to be used, giving what is practically an Oxy-Hydrogen flame of intense heat, but small in size, this being one of its chief advantages as the heating of the metal is confined to the joint. It consists of a lead tank holding Sulphuric Acid in which some fragments of zinc are placed, the action of the acid producing a supply of Hydrogen. There is also a bellows which pumps a supply of air to the burner, the two giving a flame of intense heat, but great care is required in using it or the lead beyond the joint will be fused. Very thick sheet lead may be jointed by pouring melted lead over the joint, confining it to its proper position by sand placed each side of the seam. This is seldom done except in the workshop.

In burning a flange or lug on a soil pipe or in making a pipe from sheet lead, after bending to shape place it on a roller long enough to project at both ends, which are supported by any suitable means, and tie or cramp so as to bring the edges together, bevelled to show a V shaped groove, lay on a strip of lead $\frac{1}{4}$ in. square, scraped clean, and apply a flame so that bit by bit the end of the strip melts and the melted lead flows into the groove.

In using the torch, the principal difficulty is the large size of the flame. It must be regulated to give as nearly a pointed flame as can be got. A gas blow-pipe and bellows, as used for brazing cycle frames, does the work quite as well as the usual machine, and if a supply of gas can be carried by a temporary pipe on to the roof, it will be found much preferable to the machine using acid. The ordinary $\frac{1}{2}$ in. garden hose will carry a sufficient supply of gas for the purpose. In most cases the work can be done with a "*Swedish Torch.*"

Composition and Melting Heats of Solder, &c.

Coarse Solder for Wiped Joints	Lead 3, Tin 1,	melts at 500°F.
Plumbers, fine for Gas Pipe Joints	,, 2 ,, 1	,, 440°F.
Extra fine for Gas-pipe Blow-pipe Jts.	,, 1 ,, 1	,, 393°F.
Lead melts at 610°F.	Tin melts at 430°F.	



Explanation of Diagrams.

Fig. 1—A is a pipe branched into B. C shows where the metal is wiped on to it.

Fig. 6—Is a joint as Fig. 1, shown partly in section. It will be noticed that C, the tapered end of the branch pipe does not enter the main pipe far enough to obstruct the flow of water.

Figs. 2 and 3—Show details of a wiped joint, end to end.

Figs. 4 and 5— ,, ,, gas pipe joint.

Figs. 7 and 8— ,, ,, wiped joint.

The joint shown at 4 and 5 can be used for waste water pipes, and can be made either with copper-bit, blow-pipe, or torch. If well made will stand water pressure, but is contrary to the regulations of most Water Companies and Corporations.

Weight of Lead Pipe Per Yard.

Gas Pipe	¼ in.	½ in.	¾ in.	1 in.
	15 oz.	2 lb. 10 oz.	3¾ lb.	6 lb.
Water Pipe	½ in.	¾ in.	1 in.	
	6 lb.	9 lb.	12 lb.	

These weights are the strength of pipes required to be used by Manchester Corporation and are adopted by most other Corporations and Gas and Water Cos.

Waste Water Pipes for cisterns, lavatories, baths, &c., are usually of Gas Pipe weight, as there is no pressure in them. They may be jointed like Gas Pipes.

Size of Supply Pipes from Gas Meters.

2-light meter will supply	4	ordinary	gas	burners—	pipes	required	½ in.
3	,,	,,	6	,,	,,	,,	½ in.
5	,,	,,	10	,,	,,	,,	¾ in.
10	,,	,,	20	,,	,,	,,	1 in.
20	,,	,,	40	,,	,,	,,	1¼ in.

Patents for Inventions and Registration of Designs.

By M. COLE.

* * * *

Patents for Inventions are not granted as a reward to the Inventor, but as a sort of payment for his making public his invention, so that any person may make the article when the term of the patent expires. The Inventor must describe his invention so clearly that any person accustomed to work of a similar class, can with the assistance of the description produce the same results as the Inventor. Many of the Inventors would like to evade this and obtain the monopoly of manufacture, while at the same time keeping the process a secret. A specification that does not give sufficient detail renders the patent void. The last paragraph of a specification consists of a "claim" in which the applicant must state very clearly what he claims as his invention. If any part of the claim is successfully disputed, the whole patent becomes void. The patent is granted for what is described in the claim, the remainder of the specification being merely an explanation of the method of doing the work. Any person may make a patented article in order to improve on it, but the moment he uses such article beneficially, or derives any profit or convenience from its use, or sells it, the article made becomes an infringement and the maker is liable to penalties. If any person invents an improvement on an existing patented article, and if the patentee of the original article will not purchase the patent rights for the improvement, the patentee of the improvement can demand a licence from the patentee of the original on equitable terms, enabling him to make the entire article. There is no such thing as an indisputable patent. The patent office grants a monopoly which terminates as soon as any person can show that the patent is invalid, either because the article is not new or has been sold, or used, or publicly exhibited before the date of the patent, or if the description in the specification is not complete and full enough. This may seem a hardship to the patentee, who applies for a patent in good faith believing that his invention is absolutely novel, but a little consideration will show that although the idea is new and original to the inventor, some other person may have had the same idea or made a similar article, and may have had it in daily use for years; so that if an indisputable patent were granted to the patentee, it would mean that others who (unknown to the patentee) had been using the process for years, would have to cease using it or pay royalty to someone who had conceived the idea years later. Copies of published specifications can be consulted free of charge in most large towns, but the

average inventor is so conceited and obstinate that he cannot conceive the possibility of any other man being clever enough to invent the same thing, though a few minutes search would show that the idea was far from novel.

Only a very small proportion of patents are successful, and the following are the main causes of failure:

1—The invention is wrong from a mechanical or scientific point of view. For example, an arrangement to produce motion or power by a flow of water. The water flows from a tank over a water-wheel, which in turning works a pump, which is intended to raise the water again to the tank. The wheel is also geared to a piece of machinery which it is to turn, the idea being that the pump should raise the *whole* of the water to the tank, but practically, if no other machine had to be driven, the pump could only return *a portion* of the water to the tank.

2—The invention may be before its time. This was most clearly shown in the case of the Pneumatic Tyre. Invented some 30 years before it came into practical use, it had to wait till a vehicle was designed light enough to make use of it.

3—The patentee is unable to put his invention properly on the market, and the patents for many good inventions have been allowed to lapse for this reason.

4—When the invention is neither cheaper nor better than the method in general use. This is often the case when the inventor has no practical knowledge of the business in which his invention is to be used.

In working out the details of a machine, unless the inventor is accustomed to such work, it is advisable to make the drawings on a very large scale. This enables small details to be worked out much more easily than with small drawings. In many cases a working section model can be made from card, using pins where any movable joints occur. This method is often a great saving of time and expense, as the faulty points in the design can then be seen.

Marking of Articles. *For a British Patent it is not compulsory to mark the article 'patent,' but there is a penalty for so marking an article that has not been patented. There is no penalty for continuing to mark an article 'patent' after the patent has expired, but there is a penalty for continuing to mark a design 'Registered' after the term of copyright has ceased.*

Innocent Infringement. *Any infringement of Patents granted after 1907, where the infringer does not know of the patent, is not punishable, and marking the article 'patent' is not enough notice to the public, unless the date and number of the patent are also given.*

No action can be taken for recovery of penalties for infringment of patent rights of an article that is only provisionally protected, only for such infringements as occur after the acceptance of the complete specification.

The following pages are extracts from the "Patents and Designs Act 1907," and fully explain the proceedure, and being mostly in the

same words used in the Act, are likely to be of more use than any paraphrase of them :—

An application for a Patent may be made by any person who claims to be the true and first Inventor of an Invention, whether he is a British subject or not, whether alone or jointly with any other person. The application must be made in the prescribed form, and must be left at or sent by post to the Patent Office in the prescribed manner. The application must contain a declaration to the effect that the applicant is in possession of an invention whereof he is, or in the case of a joint application, one at least of the applicants claims to be the true or first inventor, and for which he desires to obtain a patent, and must be accompanied by either a provisional or complete specification.

A provisional specification must describe the nature of the invention. A complete specification must particularly describe and ascertain the nature of the invention, and in what manner it is to be performed. A specification, whether provisional or complete, must commence with the title, and in the case of the complete specification, must end with a distinct statement of the invention claimed. In the case of any provisional or complete specification, where the Comptroller deems it desirable, he may require that suitable drawings shall be supplied.

"Chemical Inventions." *The Comptroller may require Samples or Specimens to be deposited.*

The Comptroller shall refer every application to an examiner. If the examiner reports that the nature of the invention is not fairly described on the application, specification, and drawings have not been prepared in the prescribed manner, and the title does not sufficiently indicate the subject-matter of the invention, the Comptroller may refuse to accept the application or require that the application, specification, or drawings be amended.

If the applicant does not leave a complete specification with his application, he may leave it at any subsequent time within six months from the date of application. *Extension of Time for depositing complete specification may be had on payment of extra fee.* A complete specification may be left within such extended time, not exceeding one month after the said six months, as the Comptroller may on payment of the prescribed fee allow. Unless a complete specification is left within that time the application shall be deemed abandoned.

Unless a complete specification is accepted within twelve months from the date of application, the application shall (except where an appeal has been lodged) become void.

Any person at any time within two months from the date of the advertisement of the acceptance of a complete specification, may give notice at the Patent Office of opposition to the grant of the patent, on the ground of the applicant having obtained the invention from him or from a person of whom he is the legal representative, or on the ground that the application has been patented in this country on an application of prior date or on the ground that the complete specification describes or claims an invention other than that described in the provisional specification, and that such other invention

forms the subject of an application made by the opponent in the interval between the leaving of the provisional specification and the leaving of the complete specification, but on no other ground.

If there is no opposition, or in case of opposition, if the determination is in favour of the grant of a patent, the Comptroller shall cause a patent to be sealed with the seal of the Patent Office.

Every patent shall be dated and sealed as of the day of the application. Providing that no proceedings shall be taken in respect of an infringement committed before the puhlication of the complete specification.

Where an application for a patent in respect of an invention has been accepted, the invention may, during the period between the date of the application and the date of sealing such patent, be used and published without prejudice to the patent to be granted for the same ; and such protection from the consequences of use and publication is in this Act referred to as Provisional Protection.

After the acceptance of a complete specification, and until the date of sealing a patent in respect thereof, or the expiration of the time for sealing, the applicant shall have the like privileges and rights as if a patent for the invention had been sealed on the date of the acceptance of the complete specification. Provided that an applicant shall not be entitled to institute any proceeding for infringement unless and until a patent for the invention has been granted to him.

The term limited in every patent for the duration thereof shall be fourteen years from its date. But every patent shall, notwithstanding anything therein or in this Act, cease if the patentee fails to make the prescribed payments within the prescribed times.

Neglect to pay fees *to keep the patent in force, when due to accident or negligence. The patent may be revived on payment of extra fee.*

Where any person claiming to be the patentee of an invention, by circulars, advertisements, or otherwise threatens any other person with any legal proceeding or liability in respect of any alleged manufacture, use, sale, or purchase of the invention, any person or persons aggrieved thereby may bring an action against him, and may obtain an injunction against the continuancy of such threats, and may recover such damage (if any) as may have been sustained thereby, if the alleged manufacture, use, sale, or purchase to which the threats related to was not in fact an infringement of any legal rights of the person making such threats. Provided that this section shall not apply if the person making such threats with due diligence commences and prosecutes an action for infringement of his patent.

A patent granted to the true and first inventor shall not be invalidated by an application in fraud of him, or by provisional protection obtained thereon, or by any use or publication of the invention subsequent to that fraudulent application during the period of provisional protection.

When an application for a patent has been made and a complete specification deposited, the Examiner shall make a further investigation for the purpose of ascertaining whether the invention claimed

has been wholly or in part claimed or described in any specification (other than a provisional specification not followed by a complete specification) published before the date of the application, and deposited within fifty years before that date. If the Comptroller is satisfied on this point, he accepts the specification. If not so satisfied, the applicant is allowed to amend the specification.

Until the passing of the Patent Act of 1902, there was no official search for novelty. The search is now made by the Patent Office Officials, but only so far as their *own records* go for the previous 50 years. If any previous patent seems to have anticipated the applicant's invention he is informed of it, but if the applicant still insists a patent is issued containing a reference to the cases considered by the officials to invalidate the claim.

The investigations and reports required by this section shall not be held in any way to guarantee the validity of any patent.

An additional fee of £1 is charged for the investigation.

The remainder of the Act refers to compelling a patentee to grant a licence for manufacturing the article patented subject to payment of a royalty, to compel the manufacture of patented articles in this country instead of importing them. This, and getting rid of the very numerous useless patents, being the objects of the Act.

The foregoing extracts from the Patents Acts contain the information most required by the would be patentee. The application form for Provisional Protection with £1 stamp can be obtained from any Post Office. If not in stock the officials will procure it in three days.

The drawings must be in the prescribed form or will not be accepted. A copy of the regulations as to drawings can be obtained free of charge by writing for them to "The Comptroller, Patent Office, Chancery Lane, London, W.C." The Specification can be forwarded by post to the same address, and all Patent Office routine can be done by post. Every application must be accompanied by an address to which communications can be sent by post from the Patent Office. For a Patent to be valid, the invention must not have been known in the United Kingdom before the date of the application. A description of it in a book or periodical circulating here is considered publication. The actual stamp duties payable for a patent are:—£1 on applicatfon, £3 on lodging complete specification. This gives protection for four years from date of application. If it is desired to keep the patent in force, further sums must be paid before the expiration of the fourth year, and yearly payments after that. Applicants for Patents must apply in their real names, not under assumed or trade names.

A Firm as such cannot apply for a Patent, but a joint application may be made by all the individual members of the Firm.

Patents are granted to all applicants (if unopposed) whose applications pass the prescribed stages. *The granting of a patent does not prove that the invention is a novel one, but in case of a lawsuit, the patentee's claim is good until the opponent shows that the patent is not a valid one from any cause.*

Titles of Inventions. The title of the invention should appear on the application form, and at the commencement of the specification, and the wording of the title in the two documents should be identical. The following forms of titles are not allowable :— 1—Fancy names or titles such as "The Simplex Wheel." 2—The inventor's name or the word patent. 3—The abbreviation *etc.* This must be replaced by words expressing the intended meaning of the term or by the phrase "*and the like.*"

Specifications and all other documents must be written or printed in large and legible characters upon strong and wide-ruled foolscap paper (on one side only) measuring 13 by 8 inches, leaving a margin of two inches on the left hand, and the signature of the applicants or agents must be written in large and legible hand, and the several sheets should be fastened together at the top left-hand corner.

Copies of Specifications of Patents can now be obtained at a uniform charge of 8d. including postage. A form of application can be purchased at any Post Office. Information as to whether any particular patent is still in force, the name of the present proprietor or similar details will be supplied for a fee of 1/- (by postal order) on application by post to the Comptroller. A pamphlet can also be had free of all charge and post free, giving much information useful to intending patentees, as to rules, drawings, fees payable, &c.

Patents are classified into 146 Classes, and abridgments are published at 1/- per volume for each of these classes for a period of years from 1855 to date, making 10 volumes to each class. These may be seen at the Public Library in most large towns.

Neglect to Pay Fees *to keep the patent in force, when due to accident or negligence. The patent may be revived on payment of extra fee.*

Extention of Period of Patent. *When an invention is of national importance, and the inventor has not made an adequate profit during the ordinary term, the Court may extend the term of the patent. (This power was previously vested in Privy Council.) The normal term of a patent is 14 years, the extension, if granted, is another 7 years.*

Patent must be worked in United Kingdom *or will be cancelled, but a period of 4 years is allowed before this is enforced.*

Naval or Military Patents *will not be published, but the specification will be put in a sealed packed and deposited with War Office or Admiralty.*

Royal Arms *can no longer be used by any person not specially authorised to do so.*

A patent is not invalid by reason of its prior publication by any other person without the knowledge and consent of the inventor, for the purpose of preventing him getting a valid patent.

It is now not lawful to require the purchaser of a patented article to use it or abstain from using it in connection with any other article.

If the Letters Patent are lost or destroyed, a copy can be had on payment of Fees.

REGISTRATION OF DESIGNS.

Registration is cheaper than Patenting, but does not serve the same purpose. A Patent protects the principle of an invention, while Registration only protects the shape or design. In spite of this, articles that should be patented are frequently only registered. the result being that the article may be made on the same principle, but of different design by any person without infringement. The same article cannot be both Registered and Patented, and if registered first, a patent would be invalid. The term of registration is five years. The fee is Ten Shillings for all classes, except printed or woven designs on textile piece goods or on handkerchiefs and shawls for which the fee is One Shilling. The form with stamp can be purchased at any Post Office. It is always desirable to send photographs in preference to drawings. It will be noticed that all registered articles must be marked or the registration is void.

The Comptroller may, on application by or on behalf of any person claiming to be the proprietor of any new or original design not previously published in the United Kingdom, register the design under this part of the Act.

The Comptroller may, if he thinks fit, refuse to register any design presented to him for registration, but any person aggrieved may appeal to the Board of Trade.

When a design is registered, the registered proprietor of the design shall, subject to the provisions of this Act, have copyright in the design during Five Years from the date of Registration.

The period of Copyright can now be extended for a second and third terms on payment of fresh fees, making a total term of 15 years.

Before delivery on sale of any articles to which a registered design has been applied, the proprietor must (if exact representations or specimens were not furnished on the application for registration) furnish to the Comptroller the prescribed number of exact representations or specimens of the design, and if he fails to do so the Comptroller may erase his name from the register, and thereupon his copyright in the design shall cease.

Before delivery on sale of any articles to which a registered design has been applied, the proprietor of the design shall cause each such article to be marked with the prescribed mark, or with the prescribed word, or words, or figures, denoting that the design is registered, and if he fails to do so, the copyright in the design shall cease, unless the proprietor shows that he took all proper steps to ensure the marking of the article.

"Design" means any design applicable to any article whether the design is applicable for the pattern, or for the shape or configuration or for the ornament thereof, or for any two or more such purposes, and by whatever means it is applicable, whether by printing, painting, embroidering, weaving, sewing, modelling, casting, embossing, engraving, staining, or any other means whatever, manual, mechanical, or chemical, separate or combined, not being a design for sculpture or other thing under the Sculpture Copyright Act.

"Copyright" means the exclusive right to apply a design to any article of manufacture or to any such substance as aforesaid in the class or classes in which the design is registered.

The Proprietor of a new and original design is—

1—Where the author of the design for good consideration executes the work for some other person, that person is the Proprietor.

2—Where any person acquires the design or the right to apply the design.

3—If neither of the above two cases, the author of the design.

The Patent Office issues a book of Rules and forms for Registration of Designs, price 6½d., which may be had by post by writing to the "*Comptroller, Patent Office, Designs Branch, Chancery Lane, London.*" A Copy of the Act can be had for 7d., including postage.

Taking out a Patent without skilled assistance is very difficult. Registering a design will be found comparatively easy, especially with the assistance of the book of rules issued by the Patent Office. In making the application, the class in which the registration is desired must be stated. Class 1—Articles composed wholly or chiefly of metal, not included in Class 2. Class 2—Jewellery. Class 3—Articles composed wholly or chiefly of wood, bone, ivory, papier machié, or solid substances not included in other classes. Class 4—Glass, earthenware or porcelain, bricks, tiles, or cement. Class 5—Paper (except hangings). Class 6—Leather, including bookbinding of all materials. Class 7—Paper Hangings. Class 8—Carpets and rugs of all materials, floor-cloths, and oil-cloths. Class 9—Lace and hosiery. Class 10—Millinery and wearing apparel, including boots and shoes. Class 11—Ornamental needlework on muslin or other textile fabrics. Class 12—Goods not included in other classes. Class 13—Printed or woven designs on textile piece goods. Class 14—Printed or woven designs on handkerchiefs or shawls.

In case of doubt as to the class in which a design ought to be registered, the Comptroller may decide the question.

In Registration of Designs there is an official search for novelty so far as other designs of which the copyright has not expired, and if in the opinion of the Officials of the Patent Office the new design, which it is desired to register, is an infringement on any other design in the same class for which copyright still exists, the application for registration will be refused. There is, however, an appeal to the Board of Trade against such refusal.

COPYRIGHT OF BOOKS, PICTURES, AND MUSIC.

The fact of first publication is enough to secure copyright in above without any payment or formal proceedure. The Patent Office has nothing to do with this, as it is under the "*Copyright Act of 1911.*"

A Copy of this Act can be obtained through any Bookseller, price 3d.—postage 1d.

COPYRIGHT

Making and Fixing Electric Bells and Batteries.

By M. COLE.

* * * * *

The action of electricity is best understood by considering it a current, generated in a battery, and flowing through a wire to the electric bell which it rings. It starts at one terminal of the battery, passes along a wire to a bell, where it flows through some covered wire lapped round a rod of soft iron, which thereby becomes a magnet so long as the current is flowing, but ceases to be magnetic as soon as the current stops or is interrupted. The bell also contains an arrangement that interrupts the current several times per second. Each time the current is allowed to flow through the wire forming the electro-magnet, the latter attracts a piece of iron (or armature) to the end of which is fitted a sort of hammer, which then strikes against the bell. When the current ceases to flow the electro-magnet is no longer able to influence the hammer, which is forced back by a spring to its original position, and is then ready to repeat the stroke. The part of the bell that does this work is called a contact breaker. The current after leaving the bell flows back by a return wire to the other terminal of the battery. The two wires are called the *conductors*, and the whole path throug which the current flows the *circuit*. At some convenient place in the circuit, the wire is cut and an arrangement (usually a push) is placed for the purpose of bringing the ends of the wires together when it is desired that the bell should ring, and holding them apart by a spring when the bell is not required to sound.

The parts required to fit an electric bell are: 1—The Battery. 2—The Bell. 3—The Conductor. 4—The Push or other interrupter.

THE BATTERY. For bells this should be either the ordinary form of *Leclanche*, or its modified form the *Dry Cell*. The former is preferable, being cheaper and more reliable, and is easily re-charged. It consists of a specially shaped outer vessel of glass, in this is a rod of Zinc, having a wire fastened to it. This wire forms one of the terminals or poles of the battery, it also contains a jar of unglazed earthenware called a *porous pot*. This is filled with a mixture of bits of Carbon and Manganese Oxide. In the middle of the jar, projecting above it is a plate of carbon, the top of which has a lump of lead cast on it, and is also provided with a screw and nut, so that a wire can be fastened to it. This forms the other pole or terminal of the battery. The space between this porous pot and the outer

jar is nearly filled with a solution made by dissolving *Sal Ammoniac* in water, using two ounces to the pint. When the battery is kept in a warm place, the water evaporates and should be kept to its proper level by adding more water when required. One of the jars is called a *cell*, two or more used together a *battery*, but it is now common practice to call even a single cell a battery. The Leclanche cells are made in three sizes :—No. 1, the largest size, is suitable for large hotels or where heavy work is required. No. 2 is the usual size for general use, the capacity of the outer jar is one quart. No. 3, or small size, is used for very small bells, or for other purposes than bell ringing, though often supplied with low-priced outfits. For a small bell, or on a short circuit of say 20 yards, one cell will do the work, but it is always advisable to have two cells. The same bell gives a louder sound than with one cell, or a larger bell can be used, and the power will be enough for any ordinary house circuit or up to 100 yards with an indicator in the circuit. The battery should be placed in a dry position, if possible in a box, so that no dust or dirt gets to it. The *Dry Cell* is filled with a paste that takes the required moisture from the atmosphere. It is not really dry but has no fluid to be spilled. It cannot profitably be re-charged. The small batteries used in pocket flash lamps are composed of three dry cells in series, and work well with a small bell.

There are two ways of connecting a battery of two cells. First, where one conductor is attached to both zinc terminals, and the other conductor is attached to both carbon terminals. The cells are then coupled in parallel and are equal to one cell of double the size. The battery has then the power of giving double the quantity of current. It will (other things being suitable) cause the magnet to have double the power as compared to using one cell. A second way of coupling the cells, and that generally used, is to connect the zinc terminal of one cell to the carbon terminal of the next one, and connect the conductors to the two free terminals. This is called connecting in *Series*. The battery has then the same quantity or working power as one cell, but has double the intensity or pressure (EMF—or Voltage) of one cell, and will travel through a longer length of conductor, and has more power to force its way through a bad conductor or through two bells in succession.

Connecting to the Battery. The zinc of the battery has a wire cast into it, the top end of which is tinned so that a binding screw or the conducting wire can easily be soldered to it (see soldering instructions later on. Every joint in the conductor where soldering is possible should be soldered—it is very little trouble, and the efficiency of the bell depends largely on the absence of extra resistance at the joints of the conductor. For temporary purposes the wire may be merely twisted to the wire of the zinc, but the end of the conducting wire must be either scraped with a knife, or cleaned with emery cloth till bright, and then lapped three or four times round the end of the zinc wire which should also be cleaned. A better method is to solder a binding screw to the wire of the zinc. The carbon terminal will be found to be fitted with a brass screw and nut (binding screw) projecting at the top. The surface of the

lead just under the nut should be scraped, the end of the conducting wire being also cleaned, make a half bend and screw down moderately tight, so as to bring the wire and lead surfaces into close contact.

THE BELL. The usual style is the continuous or trembler bell. This has merely to be hung on a wall by the two loops provided for the purpose. Bells as a rule are hung level, but where the current from a battery is feeble, a bell can often be helped by fixing it at an angle, so that the weight of the hammer helps the electro-magnet to overcome the resistance of the spring. This of course, is not good work, and should only be used as a temporary measure. Most bells are covered by a small wood case which is easily removable, being careful not to injure the spring in doing so. Within will be found the wire coils surrounding the soft iron forming the electro-magnet, also the contact breaker. It will be seen that the regulating screw is tipped with a bit of white metal, which is—or should be—platinum. The spring against which it works is also provided with a bit of platinum at the point of contact ; this is because the spark given each time contact is made and broken oxydises or corrodes most metals, platinum being least liable to it. With inferior makes of bells where a substitute is used, it is often necessary to clean the surfaces of the oxide formed upon them. This is best done with some fine emery cloth. The screw must be so adjusted that contact is maintained (by the point of the screw touching the platinum on the spring) during the greater part of the stroke of the hammer, but contact must be broken by the spring ceasing for a time to touch the screw, or the bell becomes a single stroke bell, which is useful enough for many purposes, but gives only a single stroke on the bell each time the press is pushed. Bells as sold are usually ready for use but sometimes it is necessary to regulate them a little by bending the wire of the hammer, which, when the armature is pressed against the electro-magnet, must be just clear of the bell or the sound will be damped by it. The amount of clearance depends on the size of the bell. For small bells the thickness of a post card is enough, for larger ones the distance is sometimes ¼ in., there being enough spring in the wire of the hammer to carry it through the intervening distance.

Solenoid Bells. The simplest form of bell is a single stroke one having a solenoid or hollow magnet. In this form the iron rod carrying the coils of wires is replaced by a tube of soft iron. Tinplate or sheet iron rolled into a tube of say three layers will do. A rod of soft iron fits easily into this to avoid too much friction, and the whole placed in an upright position. The bell is fitted a short distance above the top of the plunger. When the current passes through the coil of wire, the tube is magnetised and the plunger is violently shot out of it, striking the bell, when the contact is broken again it falls back ready for the next stroke. If the battery power is weak, the rod may be replaced by an iron or tinplate tube having a solid head. In some of the cheapest forms of bells the wire is uncovered, but is lapped so that the coils do not touch, and each layer is separated from the next by a strip of thick paper.

THE CONDUCTOR. This should be of copper wire not under 22 guage. It is quite possible to fix a bell with uncovered wire, but it is a great mistake to do so, coverèd wire being cheap enough. The proper sort for indoor use is covered with cotton and well soaked in paraffin wax, which prevents any moisture penetrating the cotton covering. The most convenient is called *Twin Wire*, and is composed of two wires, each separately covered with cotton, and then the two covered with a layer of cotton which holds them together so that they can be handled like a single wire. This is much easier to use than separate wires, and as it is well coated with paraffin wax, there is little risk of its short circuiting through accidental moisture. The wire is usually fastened to the walls by staples. Wire staples are cheapest but are difficult to drive in, and do not hold so well. The special flat staples made from sheet steel should be used. They are easier to drive being flat at the top, and are well pointed; they are wide enough to take in the twin wire conductor. Whenever a staple is driven over a wire, the wire should be protected from possible injury caused by the staple cutting the cover. This is best done, in case of cotton-covered wire, by lapping a strip of paper four or five times round the wire where the staple bridges it. For Gutta Percha covered wire a bit of thin india-rubber is best. This is easiest obtained by cutting up some ¼ in. rubber gas tube. Where a conductor is exposed to the weather, it should be of copper wire covered with Gutta Percha, and further protected by a covering of tarred tape. In using this sort be careful not to cut the insulating covering with the staples.

Flexible Conductors are a great convenience, as they permit of a bell being rung from a table or bed, without the trouble of having to approach the wall of the room; but the drawback is that they are of very high resistance compared with the line wire. A bell will sometimes refuse to ring through six feet of flexible, when it will ring freely by short circuiting just above the flexible. To avoid this, if a low resistance flexible cannot be procured, it is best to use two lengths, which must be connected so that the two conductors of each flexible are used as if they had been a single wire. For long lengths it is best to use the quality used for electric lighting purposes.

Wire under Carpets, &c. Wires can be laid under the carpets, but should be kept near the wall where possible. They may be conveniently led round the frame of a door, and to avoid making a hole in the wall, they can be laid from outside to inside a room at the top corner of a doorway, as very few doors fit too closely to prevent this. When this is unsightly or impracticable, lead the wires at the bottom corner of the doorway, and round the door frame to inside the room. Wires may also be placed under the wall-paper. If well stapled to the wall, the wire will not be noticeable under a good paper. If a very thin paper is to be laid over the wire, it is advisable to paste a strip of brown paper three inches wide over the wire, so that the increased thickness is gradual. Along the skirting board is a favorite place for laying a wire. When this is done the wire can be bought of such a colour as will match the paint, and when the board is repainted the wire may also be painted without injury to the insulation.

Hole in Wall. When this cannot be avoided, there is little difficulty in making the hole, provided a proper wall drill is used for the purpose. It is struck with a hammer same as if driving in a nail, but giving the drill a quarter turn after each stroke of the hammer. The effect is to reduce the brick in front of the drill to a powder which is easily removed.

Joining Conductors. For temporary purposes merely cleaning the ends and twisting them together will do, but a joint so made is very unreliable. The proper way is to solder them.

Soldering with Copper-bit. The easiest way to solder is using *Soldering Fluid* as a flux, and a *Copper Bit* or *Soldering Iron* which should not be under 12oz. weight. If lighter, it is apt to cool before it is brought from the fire to the job. If the tool is a new one clean the surface near the point by filing, heat till a little below red heat, and clean again with file ; then at once tin the cleaned surface by rubbing on a bit of tin on which is a little soldering fluid and some solder. The copper-bit will now be able to lift and carry some of the solder, which will leave it if the tool touches a surface of clean copper wire moistened with the fluid. If the bit is heated to redness the solder is burned in, and the point must be re-tinned just as with a new tool. The solder will penetrate the joint and bind the whole into a solid mass. The joint must then be well washed with a wet rag to remove all traces of the soldering fluid ; then, if cotton covered, lap with some narrow tape or a strip of cotton cloth, and saturate the joint with parraffin wax. Some workers use Sal-Ammoniac for flux, others use resin, but the soldering fluid is much easier to use, and if the joint is carefully washed will not injure the wire.

Flexible Conductors should always be soldered. Unlap the covering for three inches and lap the wire conductor round the main wire, solder as usual, and after washing use the unwound silk or cotton to lap round the soldered part of the joint.

Soldering with Blow-pipe. Where there is no convenience for heating the copper-bit, a candle and a mouth blow-pipe can be used. With a little practice it will be found easy to direct a smokeless flame on the joint which soon causes the solder to flow. A small portable spirit lamp is very handy for this purpose.

PUSHES AND SWITCHES. The ordinary push is both convenient and cheap. The two parts are easily unscrewed by holding the back of the push against the palm of the left hand, and grasping the box of the push with the right hand, then turning the box in the direction opposite to that in which the hands of the clock travel. Inside will be found two pieces of white metal screwed to the base, in which are also four holes. Two of the holes are for screwing the base to the wall, the other two are to allow the wires of the conductor to enter, which they do from the back. Of the two enclosed pieces of metal, one lies flat on the base board, the other is bent so as to be at some distance from the flat one, and can be pushed down so that the two touch, but it has spring enough to return when the pressure is released. A button or knob of ivory or other suitable material projects through the case when the parts are screwed together, to enable the two to be brought into contact. In good

quality pushes these are provided with bits of platinum where they touch, but the cheaper pushes are sold at too low a figure to allow of platinum being used. Each of the two metal parts is fastened down to the base by one or more screws. By loosening these a little one end of the conductor can be placed under each and held in position when the screws are tightened again, this being all that is required. In some of the more expensive pushes there is an extra screw for holding the conductor wire. Practically nearly all pushes are made this way, though they differ much in outward shape. For use with the flexible conductor, the push is either pear shape or similar to the wall push, but smaller size. Pushes for out-door work such as front doors, are usually a variety of the wall push, but of metal, and so shaped that they are easily fitted to the woodwork or brickwork of the door framing. Sometimes an ordinary wood push is screwed on the door itself, the wires being taken through. When this is done, the wires on the door are joined to the wires on the frame by a spiral formed by lapping twelve inches of the wire round a thick lead pencil or other rod, on withdrawing which the wire remains in a spiral form. This spiral should also be used for the ends of the conductor where they join the bell, also at the battery. It allows of their being joined more easily, and gives a finish to the work.

Switches. The simple switch shown in the diagram is used to cut out the bell when it is not required to work, it also forms an easily made substitute for the push.

Secret Push. It is often desirable to be able to ring a bell without having a visible push. This is specially useful on a front door. The simplest way of doing this is to fix two screws in either the panel or frame of the door. They should be of brass with round heads, and placed about half-inch apart. To ring the bell it is only necessary to touch the two screw heads with a coin or other bit of metal. The screws project through the door on the inside, and the line wires are soldered to them. There are many special devices to ring a bell when a door or window is opened or closed, or in walking over a doormat. There is no difficulty in fixing these.

Fixing Push to Wall. Where there is woodwork this is no difficulty, as it merely requires screwing on, but fixing to a plastered wall will be found more difficult, as the nails or screws do not hold well. If there is any wall paper to match that upon the wall the job is much easier, but when the push has to cover all the fitting, greater care must be used, and a large sized push will be required. To fit, cut away the plaster with an old chisel till the bricks are reached. The hole need not be more than two inches square, and should be larger at the bottom than the surface. Provide a piece of wood smaller than the hole, and of the thickness of the plaster, which should also be bevelled to hold better. After removing any loose plaster from the hole, wet the plaster, and having inserted the piece of wood, fill up with Plaster of Paris mixed with water to a paste. If the plaster of the wall is not wetted, the Plaster of Paris will not set properly. When the job is dry, the push can be screwed to the inserted wood. This method is both easier and better than the usual way of plugging the wall.

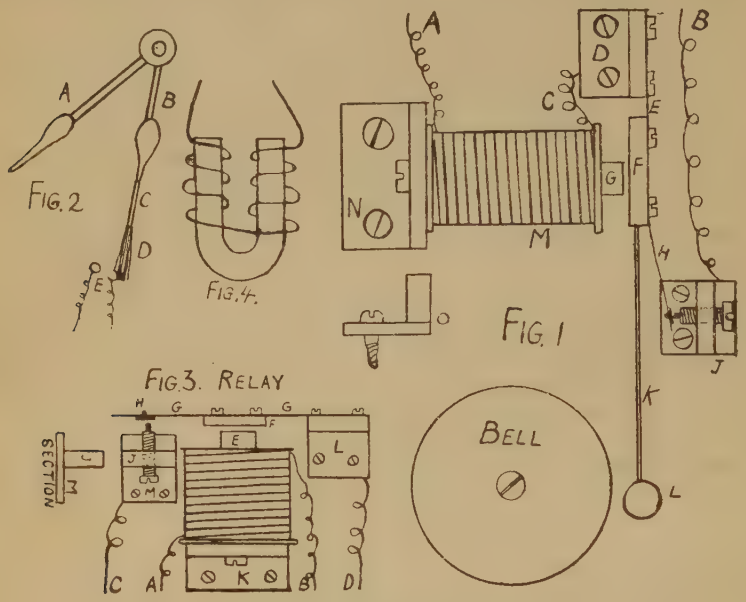
Several Pushes to One Bell. There is no difficulty in doing this. The bell and battery should be placed close together, and *no push between them.* The two conductors, one from the bell, the other from the battery, are joined to a push at the most *distant* part forming the main circuit. Any number of branch circuits can be made by connecting one wire of the branch to each of the main conductors (of course without cutting the main conductor) at any place, and carrying the two branch wires to the desired point where they are united to a push. These branch circuits may also be tapped, and other branches taken from them. Always fix the most distant part first to form the main circuit, and see how the bell rings through that length of wire. When making branches, complete one branch before starting another, there can then be no confusion.

Indicators for Bells. The same bell may be used for several rooms if the various wires pass through an indicator before reaching the bell. The forms of indicators are too numerous to describe, but in all of them the current has to pass through an extra coil of wire, but which instead of striking a bell causes a colored or numbered disc to move. There is no difficulty in fixing these for anyone who can fix a bell. They all require more battery power than an ordinary bell, and are very apt to get out of order. When fitted in private houses they seldom have enough battery power to work well.

Hole in Wall. When a wire is to be taken through an inner wall of a house there is much less difficulty than with an outer wall. With a long thin bradawl, try the wall by driving the bradawl in with a hammer with gentle taps, till the sound and resistance shows that a brick is in the way. Then try again $\frac{3}{8}$ of an inch below that and continue till the layer of mortar between the bricks is met with. This cannot be more than three inches, and if the bradawl is thin, the trial holes are not noticeable. Having found the joint, the mortar can be pierced by twisting a screwdriver to and fro, till the mortar crumbling before the end of the blade, allows the screwdriver to pass the whole of its length through the wall. The screwdriver must be one having a thin round shaft, and larger at the tip than the shaft. A bit of metal suitable for the job is easily made.

Testing for Faults. If a bell has been fixed some time and stops ringing, the cause is probably the battery has run down. If of more than one cell, take each cell and connect separately to the bell which it should ring through short circuit, or test the cell by taking a wire from each terminal and placing the ends on the tongue, if any current passes a peculiar taste will be experienced. If the zincs are corroded it is best to replace by new ones. If bell hammer trembles but does not sound, try adjusting the screw, and clean the end of the platinum wire tip of the screw, also the bit on the spring. If both bell and battery are right try the push, see that the surfaces that touch when pressed are clean, and if not scrape them. If none of these the fault will probably be found in the line wire between the push and the bell; see if a staple has been driven in too far so as to cut the insulation. Short circuit the bell at some point between the push and the bell by scraping the insulation off the two wires for $\frac{1}{8}$ in. and connecting the two with a bit of copper or brass. If this rings the bell, the fault is further away, if it does not the fault is between

the test place and the bell. Scrape the ends of the wires where they are connected to the bell, also the surfaces of the binding screws they touch, and screw up again. See is the line wire in a damp place in any part of the circuit.



How to make a Bell and Battery.

The following instructions show the easiest way of making a bell and battery. The bell is shown in the diagram above, fig. 1 The parts N.D.J. may be made of brass, the thick parts soldered to the thin ones, shown in section at O. N. is a bracket to carry the electro-magnet M, the end of the core of which projects at G. It is shown screwed to the bracket, but will do if rivetted. The wire for the coil is 20 or 22 B.W.G., silk covered, using about 1½ oz. for coil 1½ long by 1⅛ outside measure. It is usually wound on a wood bobbin, the stem of which is very thin so as to get the wire as near as possible to the core G.—the winding must be very even. In some bells the bobbin is omitted and the wire wound on the core. The armature F. is of soft iron, this and the core should be made red-hot, and allowed to cool slowly by burying them in hot ashes. A piece of steel spring, E.H. reaches from the bracket D. to the contact screw J., the armature F. is screwed or rivetted to it. The end opposite to the screw, and the screw itself, are tipped with platinum. This is done by drilling a hole in the screw-end and inserting the wire, the tip for the spring must be rivetted to it. The screw J. must be so adjusted that when F. touches G. there is a small space between the two platinum tips. The spring may be made from the steel ribbon sold by drapers ¼in. wide. The bell may be either screwed down by a short screw—the hollow side

being outwards—or screwed by a long screw, using the stem of a cotton reel to raise it above the base board. The current enters the bell at A, travels through the coil M, the wire C to D, thence along the spring E.H. through contact screw J. to the other terminal B.

The core of the coil is ⅜ in. thick and 1¾ in. long, this allows ¼ in. to project through the reel. Most bells are made with two coils side by side, in this case the two ends of wires from inside the coils are soldered together, and the two outer ones treated as if they were one coil, the coils being placed so that the soldered ends are next to the base-bracket. Fig. 4 shows how the wires are lapped when a horseshoe-shaped magnet is used.

The Relay.—Fig. 3. This is most useful when the bell has to be rung through a great length of wire. The relay is an automatic push worked from a distance. The conductors from the distant battery are attached to the terminals A.B. The magnet E. attracts the armature F. which closes the circuit D.L.G.H.J. to C. and allows the current from a local battery to reach the bell. This is a much better method than using great battery power from a distance, as a very weak current will work a relay which would scarcely have any effect on a bell at the same distance.

Converting Ordinary Clock to Electric Alarm. The easiest way to do this is shown at fig. 2. The hour-hand has a strip of thin steel (painted white) soldered to it, the end being a small brush of very fine brass wire. The wires from the bell and battery are led to the two small brass knobs E. At the required time the brass touches the two knobs at the same time and closes the circuit.

Making a Battery. For a Leclanche cell, a flat carbon plate is required, long enough to project 1½ inches above the porous pot. A length of tinned wire should be twisted three or four times round the plate at the top end, and some lead cast on to form a cap to the top end of the plate, which will also protect the wire lapping. The lead must be well coated with black tar paint, the projecting wire will form one of the terminals. The porous pot must be steeped in melted paraffin wax for 1 in. at top. The carbon plate being inserted in the jar, fill up with a mixture of equal parts of broken carbon (not smaller than peas) and oxide of Manganese, then pour some melted pitch on the top to seal it, leaving two small air holes, or insert two bits of small glass tube for the purpose. A zinc rod must be cast for the other pole, a wire being introduced at the same time to form the other terminal. The mould can be made by lapping several layers of brown paper on a rod of ½-in. wood, on withdrawing which a tube is left. This should be placed in a jar and surrounded by sand. The zinc can be melted in an iron ladle, and must be pure. After casting it must be amalgamated by dipping in dilute sulphuric acid, and while wet rubbing with quicksilver until the surface has a coating of it. A rag tied to a stick should be used for this purpose. A strip of ordinary sheet zinc can be used instead of the amalgamated rod, but the effect is not so good. When a porous cell cannot be procured, a bag of fine canvas can be used in its place, but it is not so durable.

A form of cell easier to make, but not so effective as the Leclanche, is by tying together with rubber bands some carbon rods as used for arc electric lamps. To one of these a wire is connected by a cast lead cap—the other pole is a strip of zinc, no porous pot being used. The fluid required is 2 oz. of Sal Ammoniac dissolved in 1 pint water.

The simplest of all forms of cell is a plate of copper and one of zinc in a jar of water in which a few drops of sulphuric acid have been poured. *CAUTION.*—In all cases where water and acid have to be mixed, the acid must be poured slowly into the water, *NOT the water into the acid,* or an explosion will occur.

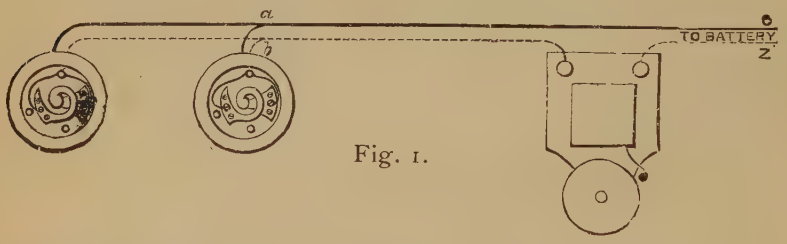


Fig. 1.

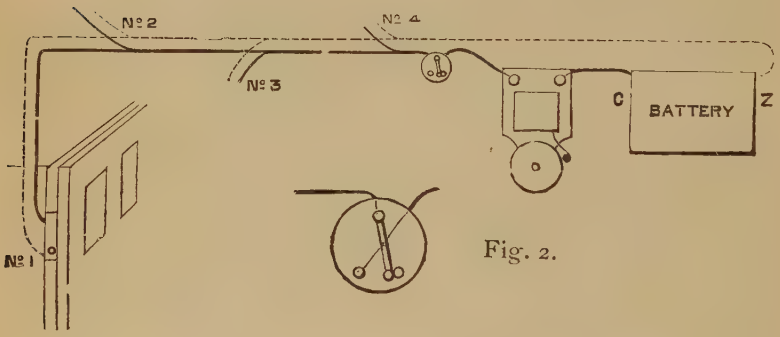


Fig. 2.

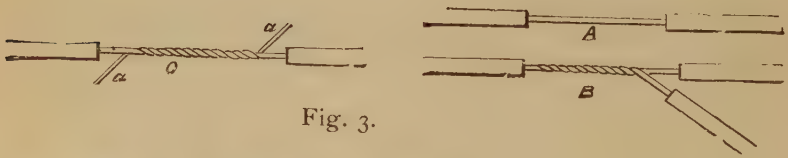


Fig. 3.

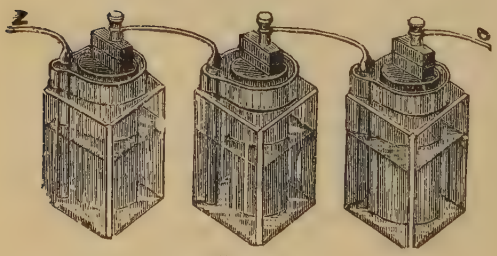


Fig. 4.

Fig. 5.

Description of Diagrams. Fig. 1 shows the usual method of fitting a bell with its battery, pushes, &c. The battery is not shown as it is supposed to be placed in a cupboard or other place out of the way. The pushes are shown with their covers removed.

Fig. 2 shows another method. In this case the conductors are led to a door in the frame of which is placed a special door contact, which rings the bell when the door is opened. Other shapes of contacts are made to cause the bell to ring as the door is closed. A switch is shown in the circuit near the bell, (shown also in a larger size). This, as placed, is to cut off all the pushes from the bell, so that it cannot be rung from any of the pushes when the switch is open. It could be placed near the door contact to cut off that one only, without interfering with the action of the other pushes.

Fig. 3 shows how the wires are joined up. A being the wire with the insulating material removed from a portion of it. B shows how a wire is branched from the main conductor, being well twisted together before soldering. C shows how the ends are to be twisted together in joining wires.

Fig. 4 shows three cells of the ordinary Leclanche shape joined in series, as they usually are for electric bell work.

Fig. 5 gives details of the push (the cover being removed). The two bits of shaped sheet metal form the contact pieces, and in pushes of good quality these are tipped with platinum. One of these lays flat on the base, the other one (the curved piece) is, when at rest, some distance above the straight one, but can be pushed down when required until it touches the flat one, and so completes the metallic circuit through the bell and wires, from one terminal of the battery to the other one. The ends of the two conductor wires are seen brought through one hole, and then separating are screwed one to each of the sheet metal contact pieces. The other two holes are for screws for fixing the push to the wall. The wires are stripped of their insulation for a little distance from the ends, and scraped clean, but great care must be used that the two wires are thoroughly insulated from each other where they go through the hole in the base, or the result will be a leakage of current. In some makes of pushes there is a special screw to hold each of the wire ends, in others the ends of the wires are placed under the contact piece and held down by screws. The conductors should be of copper 20 or 22 B.W.G., cotton covered, and well soaked in paraffin wax for indoor work, but where exposed to the weather the insulator must be gutta percha. If for very damp places, the insulation must be india rubber protected by tape well paraffined. For indoor work twin-wires are much the easiest to fix.

Hanger for Battery. A board ½ in. thick, 12 in. long, and 8 in. wide is the proper size for this. Cut off the two top corners and make a ½ in. hole about 1¼ in. from the top, to hang the board by. To the bottom edge nail a strip of wood 1½ in. square, or fix a board 4 in. wide by two small brackets, to form a shelf to hold the two cells. If only the wood strip is used, the two cells are tied on

with stout copper wire. The bell and battery may be hung close togther on a dry wall, they are then both out of the way yet easy to get at. This arrangement has the disadvantage of allowing the fluid to evaporate quickly, but it is an easy matter to pour in water to replace the loss from a small jug.

Portable sets of bell and battery are very useful for sick room or when travelling, for this purpose dry cells should be used. Two of them fitted in a box that fits them well, and the bell screwed on the outside. The conducting wires can be laid on the ground close to the wall, and under the door. A few staples will secure the wire.

Earth Return. It is not absolutely necessary to use two wires the whole distance between the push and the bell. One can be saved by using gas or water pipes in its place as part of the circuit, as is done in long distance telegraphy, but now that there are so many installations of electric supply for lighting, &c., there is always the danger of a heavy current leaking into the bell circuit. The saving is so little in in-door work that it is not worth while, but for long distance work it is often done. In case of a bell line between two houses, the second wire can be fixed to the gas or water pipes in both places, the main pipes and the earth between them forming the return of the circuit.

Metal Covered Wire is now very much used for out-door work. It consists of a central copper wire well insulated with rubber and tape, and enclosed in an outer covering of lead, forming a tube which can be used as the return wire. It is not dear, and is the best for out-door work or in damp places.

Electric Night-Light for Clock or Watch. Where a small light is required for a few seconds only, say to illuminate the dial of a clock or watch at night, the lamp may be worked by the same battery used for a bell. A special lamp is required (3 volt) to work with two cells Leclanche in series, and it is fitted up exactly as a bell would be, the lamp taking the place of the bell. The lamp, which is a very small one, must be fixed very close to the clock and a reflector placed so that the light is thrown on the dial. The push, which should be pear shaped, is fitted at the end of a length of flexible conductor, so that it can be used without getting out of bed. The reflector may be of white paper, which reflects as much light as a silvered surface. The light should never be used for longer than a few seconds at the time or the battery will run down, it will however recover itself if allowed to rest a few hours.

Bells in Coal Mines. In the usual forms of continuous bells there is a spark at the contact breaker at every stroke of the bell, and there is reason to suppose that several great colliery explosions were caused by such sparks. This can be prevented by using single stroke bells in the mines, but there is also a spark in the push when making contact in ringing a bell, and again when removing the pressure. This can be made harmless by enclosing the push in a bag of sheet rubber thin enough to allow the knob to be pressed down.

COPYRIGHT

THE SAW

and How to Use it on Wood and Metal.

By M. COLE.

* * * * *

The oldest form of saw was a jagged edged flint, set in a handle of bone or wood. Those of a later date were of bronze, and in use before iron was used for industrial purposes, being too scarce and valuable for other purposes than weapons. In the middle ages, when steel was still very dear, the saws and many other tools were made from iron and case-hardened, a method in practice until a comparatively recent date. Saws of these classes were, however, little more than narrow files. They did not make a clean cut, but scraped away the wood, &c., in fragments. The modern saw consists of a number of small knives, each having a properly sharpened cutting edge (terminating in a point) each of which makes a clean cut. One result of the low quality of the old saws was that they had to be used to cut in the *pull* stroke instead of in the *push* stroke as modern ones do. Some of those now in use cut with both strokes, but these are only used for rough course work. The teeth of these old saws were consequently in the opposite direction to those we use, and this style of saw is still used by many eastern nations. A low quality metal will stand the pull stroke, but would break on attempting to cut by pushing it. Those narrow saws that are strained in a frame, such as fret saws, sweep saws, &c., are used in this way to cut while pulled towards the worker. If used the other way they soon break, often at the first attempt. Hack saws for cutting metal are among the reversed ones.

Saws in General Use are of the following classes :—

HAND SAWS (so called to distinguish them from the two-handed pit saws, &c.) consisting of a flat blade and pierced handle.

1—**Ripping Saw** or **Rip Saw** with coarse teeth, used for cutting soft wood in the direction of the grain. These cut rapidly, and the widely spaced teeth do not clog so soon as those of a finer saw would. They are, however, of little use with hard wood or for cutting across the grain.

2—**Cross-cut Saw,** or more generally called **Hand Saw,** and if with fine teeth, **Panel Saw.** This is the shape that does most of the cutting in joiners' or cabinet makers' workshops.

Key Hole Saw, a smaller form of the hand saw, terminating in a point so as to enter in a hole made with a centre-bit. A variety of this is the **Pad Saw,** having a round handle with hole through it lengthwise into which the blade fits when not in use. When used, the blade is held by two screws in the ferrule of the handle. Both of these saws are of very soft metal, so that they bend when one of

ordinary temper of the same section would break. It would be an advantage if these saws were made to cut in the pull instead of the push stroke.

BACKED SAWS. In cutting fine work, in order to get a very narrow saw-cut, a saw with a thin blade must be used. If not in some way supported, these would be too weak for the purpose, and also liable to bend in using. They are therefore strengthened by a rib of brass or iron having a groove in its length into which one edge of the blade fits. These must be used with care to avoid buckling or bending the blade. They are made in many sizes, from 8 to 24 ins. long for various requirements of cabinet makers, picture framers, &c., others much smaller, 3 to 6 ins. long with blades little thicker than note paper. Those most used are:

1—**Tenon or Dove-Tail Saw,** 8 to 16 inches long, having from 8 to 16 tooth points to the inch, and backed with brass or iron. The smaller sizes have open handles, the larger ones closed.

2—**Straight Handled Back Saws,** a smaller form of dove-tail saw, with round handle, very thin blade and small teeth, suitable for delicate work.

3—**Metal Cutting Backed Saw or Ward Saw,** much used by locksmiths, &c., in preference to the Hack Saws in frames, as it is less liable to breakage, though slower and dearer than the thin saw.

TENSION SAWS, consisting of a narrow blade strained in a frame by a spring, screw, or twisted cord.

1—**Sweep or Bow Saws.** The blade, sometimes less than a quarter of an inch in width, is strained in a wooden frame. Its narrowness enables it to cut in a curve. It is much used with broader blades on the continent instead of the hand saw; also for rough wnrk, such as cutting up logs of firewoop, for which purpose it has large teeth far apart so as not to clog. Some are so arranged that the blade can be swivelled so as to cut sideways to the frame.

2—**Fret Saws** for cutting very thin wood, and strained by the spring of the frame itself.

3—**Hack Saws for Cutting Metal** are a modification of the fret saw, using blades about ½-inch wide and the teeth fine and slightly set. These are useful for fine wood cutting. This refers to the American Hack Saw, the old English shape being thick blade, coarse teeth and very little set, was slow cutting and heavy to work.

SPECIAL SAWS, for instance, a long narrow saw similar to the keyhole saw, but having half the edge of the blade at right angles to the remainder—a very useful tool for cutting a square hole. Starting with a centre-bit hole, the end of the saw cuts as far as was required, then the second part came into use starting a cut at right angle to the first one, which could then be extended by using the point part again. Others are ripping and log cutting saws having large and specially shaped teeth, and many others.

Machine Saws of many kinds—circular and gang saws, band saws, veneering and other kinds—will be treated in another section.

Saw Teeth. If the teeth of a good saw are examined, it will be seen that each is a knife, ground at one side like a joiner's chisel, which leaves the top of the tool pointed, and it will also be seen that each tooth is bent away from the centre line of the blade. In some

saws each tooth is sharpened at both its edges (not at both sides of one edge) so that it cuts in the push and pull stroke. These teeth differ a little in shape from the other teeth having only one cutting edge. The shapes of saw teeth vary with the work they have to do. While all the smaller saws cut in one direction only, rip saws and two handed saws, also American pattern log saws cut in both directions.

How to Choose a Saw. A fair outfit for a woodworker would be :—

Rip saw.....	28 in.	long...	4 points to the inch.
Hand saw.....	26 ,,	...	6 to 7 ,,
Tenon backed saw	14 ,,	...	10 to 12 ,,
Dovetail ,, ...	10 ,,	...	14 to 18 ,,

Also Pad saw, Sweep saw for curves, and Hack saw for metal. In all saws it is important that the handle should be comfortable and fit the hand well, and the saw well balanced, *i.e.* : in a hand saw or rip saw, when held in the cutting position it appears to weigh less than if held in any other position. It should also be thinner at the back than at the cutting edge, apart from the set of the teeth. The blade must be capable of being bent into ¾ of a circle without taking a permanent set. Some of the more expensive saws have smaller teeth for a few inches near the end to make a start easily in the work. In all saws, the thinner the blade is the easier it is to work, and good quality saws are always thinner than common ones of the same size and class. Look also at the finish, good saws are not sent out dull and old looking, they have a bright, highly finished appearance. For picture frames and other small work, a saw with very small teeth should be used as it leaves the work nearly smooth. Don't buy a second-hand saw, unless it is from someone who thoroughly understands a saw and can guarantee it to be a good one. New saws sold at second-hand shops are always bad, but good old saws can often be bought cheaply. Small size hand saws are made for amateurs' tool chests, which are usually too small to hold a full sized saw. These do not give scope for the whole arm to work. A full sized man requires a full sized saw to exert his strength, with a small one there is much waste of energy. For odd jobs, however, the 18in. Chest saw (a small hand saw) is a very useful tool. Backed saws in particular are liable to be twisted or buckled, so should be examined before buying.

USING THE SAW ON WOOD.

Always mark the work before cutting, it does not take long and saves a lot of trimming up afterwards. For rough work a pencil mark will do, but for any exact work the mark must be made with a metal point or sharp edge, especially if cutting dovetails. In marking, allow for a shaving being taken off afterwards with the plane, and use a square to get a square cut. If merely dividing a bit of wood it is enough to cut along the line, but if the work has to fit another piece, cut so as to *leave* the line or pencil mark.

Work must be fastened down any way so long as it does not move. Long work will keep steady on the sawing tressle by putting the knee on it, and should be about the height of an ordinary chair, a couple of boxes are often used instead. Smaller work can be held in the bench vice, or cramped down with screw cramp or carver's

screw or even nailed to the bench. A bench sawing stop is very easily made and just the thing for small jobs. It is usually cut out of the solid, but one can be knocked together out of odd bits in a few minutes. Take a bit of board 12 in. long, ½ in. thick, 4 in. wide, at one end nail on a bit 1 in. thick, 4 by 2, nail a similar bit at the other end but *not* on the same side of the large piece. See that one of these pieces is nailed or screwed near its ends only, and at half its length make a saw cut in it so that it becomes two bits, each 2 by 2 by 1 inch thick, side by side and separated by a narrow slot that will just allow the saw blade to enter. The work to be cut rests against these two blocks, the other block catches the edge of the bench and prevents the whole affair moving when using the saw. With all saws stand so that you look down the whole length of the saw, not one side only. *Cut slowly.* Those who know least about saws always use them quickest, while a good sawyer cuts with a steady slow stroke, but continues to cut long after the quick one has got tired. It is not necessary to press the saw on the work, if sharp it will grip well enough if merely moved up and down, if not it requires to be sharpened. In making a long cut, the parts already cut are apt to close and bind the saw. To remedy this, wedges should be inserted to keep the cut open. In cutting a long piece of thick wood, it is well to cut a few inches each side alternately, there is then less risk of cutting crooked. Cutting with a backed saw is much easier as the work is closer to the eyes, and being on a bench easier to work. This also should be used slowly, and never on any account cut without the work being held or fastened to the bench, or the saw will get buckled.

METAL SAWING.

Metal Sawing is done with a *Hack Saw*, a narrow blade strained in a frame. Those now mostly used are of American make, very thin in the blade and having fine teeth slightly set. They cut rapidly, remove very little metal, and are so cheap that they are never resharpened. The older styles were twice as thick in the blade, coarser teeth, and being more expensive were filed up as many times as required. To do this it was necessary to leave the blade softer than the later form so they had not so much cutting power. Another form of metal saw is the *Screw head saw* or *Ward saw*—still a favorite with locksmiths, blacksmiths, and jobbing mechanics on account of its power of standing rough usage. It is similar to the Dovetail backed saw. Even with these rough workers it is rapidly being replaced by the American saw.

In cutting metal the saw must be used slowly and kept well greased and great care used to prevent twisting, what would cause other saws to buckle would break one of these. Frames are arranged to take the saw blade in four positions, often a great convenience to the worker. Before sawing steel it should be annealed. Some special saws similar to fret saws are made for cutting metal. There are also some about double the width of a fret saw. A good quality dovetail saw with fine teeth will cut brass, and is often used for the purpose. Plumbers' saw for lead is the ordinary keyhole saw, which has very little set on it.

HOW TO SHARPEN AND SET A SAW.

The filing of the teeth must be done before setting them. The saw must be fixed firmly either in a special filing vice, or between two slips of wood pinched in the bench vice, or by other means.

Topping is the first operation. To bring the top of the teeth quite level, a file without handle is laid on them lengthwise, and rubbed down from the handle to the end of the saw, repeating as often as required to bring them level. Any teeth below the line do not do their share of cutting, but there will always be some such, and broken teeth cannot always be avoided. This is of less consequence than a few teeth being *higher* than the bulk. The file used is the three cornered one and is single cut, files for ordinary purposes being double cut. An ordinary flat smooth file may be kept for topping.

Filing the Teeth. The position of the file on the teeth depends on the shape of the teeth, and the angle of the cutting surface required. A safe and easy rule is "*Put a new surface at exactly the same angle it had before.*" If it is intended to alter the shape or cutting angle of the teeth, the job should be given to a saw cutler, while to follow the old lines is easy and requires only a steady hand. Push the file with a slow and steady stroke so as to use the whole length of the file. On the return stroke, either lift it clear or allow to rest vey lightly on the saw. Two strokes are usually enough for each tooth of a hand saw, while small tooth backed saws are usually done with one stroke. Don't use an old file full of dirt, and if a new one is bought keep it clean and well oiled.

See that the toothed edge of the saw is very little above the edge of the vice top, only enough for the file to clear it. Start at the end nearest the handle and file each alternate tooth, then reverse the saw and file the remainder. While the file is cutting the slanting edge of one tooth, see that it does not at the same time touch the adjoining edge of the next tooth.

Setting the Teeth. The correct way of doing this is with a single stroke of a special hammer on each tooth. The saw-edge rests on a sort of anvil, part of the edge with the teeth overhanging. This, however, requires a good deal of practice to do it evenly. The easy way is with a tool called a "sawset" of which there are several shapes. The plate shape having several notches to fit various thicknesses of saw plate is an old but useful form. The tooth to be set is inserted in a notch, and bent by using the handle as a lever. Other forms are capable of adjustment so that there is no danger of uneven bending. Some work by pressing a lever, others by a stroke of a hammer on the head of a punch, the lower end of which presses on the tooth to be set. The amount of set varies with the work to be done by the saw. The rip saw, and those for cutting damp wood must have more set than a dovetail saw used only on very dry wood. Setting a saw is quite as important an operation as sharpening it, but a saw need not be set every time it is sharpened. Too much set is as bad as too little, in the former case a larger quantity of wood has to be reduced to sawdust, while with too little set the saw will *bind* or touch the sides of the cut and cause extra labour by the friction. The setting must be done near the point of the tooth. Teeth

are usually broken by attempting to get the bend too low down. The tooth does not always break at the time of setting, but cracks, breaking off while cutting.

Re-Toothing a Saw. A good saw having many teeth broken is well worth a new set of teeth. This has to be done by a saw cutler, who cuts off a strip at the edge with all the old teeth, and punches new ones in the new edge. It is quite possible to do this by hand, but it is a very tedious job, though in all early saws the teeth were always filed out, the punching press being of comparatively modern introduction.

The Triangular (or 3-square) file does for all saws in ordinary use by hand, but large circular and other large toothed saws are filed with a flat file specially made for the purpose. and after a certain amount of wear these require *gumming* or *gulletting*, that is, the space between the teeth deepened.

Protecting Teeth of Saws. All small saws kept with other tools or carried about should be protected by a bit of wood the length of the saw by about ½-in. square, leaving a saw-cut lengthwise ¼-in. deep, which may be tied on with string. It saves sharpening and prevents accidents.

Cutting Ivory and Bone. Use a saw having very thin blade, fine teeth, and little set; an American hack saw does well for this. Cut slowly, use no oil or grease or it will disfigure the ivory, but either dry or with plenty of water which will wash the dust out, while a little water will make a paste of it that will remain in the cut. Ebonite is cut with a saw suitable for brass.

Band Saws. The blades for these are sent out by the makers in very long lengths. The required length having been broken off, the ends must be brazed together to get an endless band. From the nature of the saw and its work, it is important that the joint should be no thicker than the remainder of the saw. If carefully done it will be so. There are several ways of heating the joint, many workers using the gas blow-pipe. This should never be used for the purpose as, however quickly used, the sulphur in the gas makes the steel at or near the joint brittle. The right way is with *hot tongs*. In any case the parts must be held in position by a suitable vice which will prevent any movement while the job is being done, yet allowing the tongs or gas flame to get on the joint. File away enough from each end of the saw to bevel it for a length of three teeth. Put between the surfaces some borax powder and some fine grain spelter (brazing spelter *not* zinc which is often called spelter) mixed with a little water to a paste. Arrange the parts so that the teeth of the scarfed parts just fit on each other, then (if for gas) tie up with some soft iron wire to hold in position, and apply the flame of the blow-pipe to joint till the spelter melts. At once grip the joint with a pair of tongs made hot, and hold together till it cools. In order to economise gas a reflector should be made of asbestos sheet ¼-in. thick, which will form a kind of hood covering the joint above and below, and keep the flame on the work. A better way is to use

a pair of tongs having very heavy ends, also a pair of light ones having thin ends. The light ones being heated are put so as to grasp the joint, the heavy ones are heated almost to white heat and put so as to grasp the joint over the light tongs. The heat of the heavy tongs is great enough to melt the spelter and they can then be removed, the light pair being kept in place until the joint is well set, to prevent the parts opening. A fork or block of iron at end of a long handle and having a slot in it can be used instead of the heavy tongs, but should fit easily over the light ones. The Swedish Torch largely used by plumbers is very useful and suitable for brazing Band Saws.

Silver Solder should be used for all band saw joints. It melts at a much lower heat than spelter, and only a small quantity is used. It is in thin sheet, cut off enough to go inside the joint, use with wet borax and there will be scarcely any file work to do, while if spelter is used there is a lot of dressing up of the joint to get it same thickness as the remainder of the saw. Band saws after being several times joined up are, though still very serviceable, usually thrown away at the saw mills. A length should be got to practice on, either brazing or sharpening and setting the teeth.

Cutting Nails. Before commencing to cut old wood, nails must be carefully looked for along the line to be cut. Even the smallest tack will spoil the sharpness of a saw. Nails that cannot be pulled out must be forced through with a punch, even then the rust left in the hole is bad for the saw. At public saw mills, half-a-crown is charged for every nail the saw cuts into. The sound given by the saw when it touches a nail is easily recognised, and must be taken as a warning not to proceed until the nail is removed.

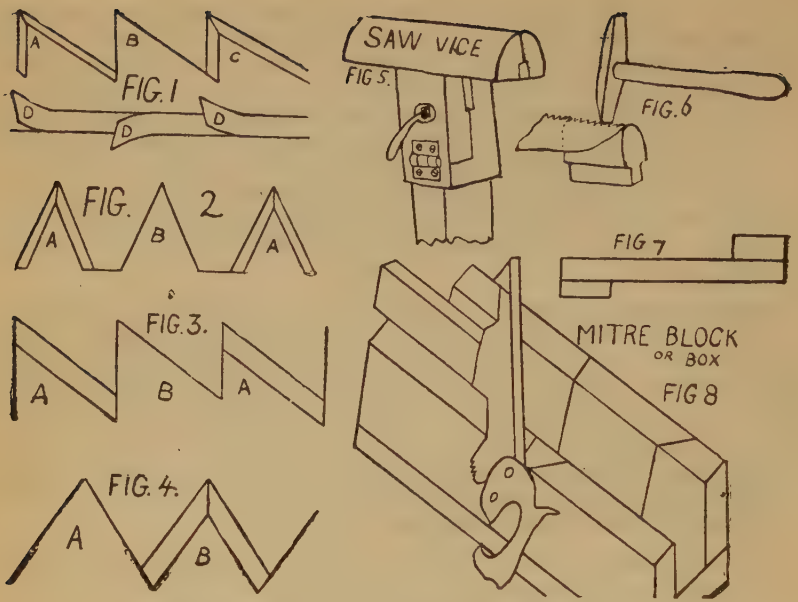
Rebate Saw, for cutting a rebate such as in picture frame moulding, is easily made from a bit of old saw, screwed or cramped to a block of wood, A little of the wood is cut away behind the saw, forming a guide so as to make an even saw-cut along the length of the wood beading. This method is much quicker than the rebate plane.

Depthing Guide for Saw is made by cramping a strip of wood one or both sides of a backed saw, at such distance from the edge as the depth of the cut requires.

DIMENSIONS OF SAWS.

Without Backs.	Length	Points to 1 in.
Rip saw	28	4
Hand or Cross Cut	26	6 to 7
Panel	20 to 24	10 to 11
Keyhole or Compass saw	14 to 18	9 to 12
Backed Saws.		
Tenon	10 to 14	10
Dovetail	8 to 10	14 to 18
Straight handle	3 to 6	18 to 40

In measuring saw teeth, reckon the number of points to the inch, not the teeth.



EXPLANATION OF THE DIAGRAMS.

Fig. 1 shows the teeth of ordinary handsaw. A and C show the sharpened sides of the teeth, B shows the side not filed which is bent away from the other two, which are bent point outwards. In this case the front of the tooth is filed. D shows the amount of the *set*. It will be seen that a line drawn lengthwise will be overlapped by the heels of all the teeth, thus preventing a ridge forming between them.

Fig. 2 shows a quick-cutting form of tooth for two-handed cross cut saws, or for pit saws. It cuts equally well in either direction, but requires a thick blade or the teeth break off.

Fig. 3 shows the form of tooth most in use for hand and backed saws, also for band saws. The teeth are filed on the slope only.

Fig. 4. Rip saw for soft wood, the teeth cutting both ways. This shape of tooth, being set closer, is stronger than at Fig. 2.

Fig. 5. A good form of screw-vice and easily made. If the leg is long, and two pegs are at back of the jaws to rest against a wall, this form makes a good portable vice.

Fig. 6 shows how the saw-teeth are set with a small hammer on anvil block.

Fig. 7. Bench stop for sawing small work.

Fig. 8. Mitre Box, with length of work being cut by backed saw. If the back of the box is omitted it becomes a mitre block, but this form is not so good a guide for the saw as the box.

COPYRIGHT

French Polishing,
and the use of Stains and Varnishes.

By M. COLE.

* * * * * *

French Polishing and Varnishing are both methods of coating wood, &c. with a layer of Lac or other resins or gums. In varnishing, these are in a fluid thin enough to use like a paint, the solvent evaporates and leaves a coating of gum or resin, but the drawback to this method of working is that the coating never sets as hard as when used in the form of a polish. In polishing, the fluid is applied by rubbing. The heat caused by the friction evaporates the spirits used to dissolve the resin, and so deposits a thin layer of the resin. A number of layers are thus formed, each one drying before the next one is deposited. The result is a hard body of lac, transparent enough to show the grain of the wood on which it is placed. Most woods are so porous as to allow a great deal of the polish to sink into the pores, unless some means are adopted to prevent its doing so. It also often happens that the wood to be polished is not the same shade all over the piece, or is too light in colour for the article to be made from it. In both these cases stains are used to give the desired tint, though whether the appearance is really improved by the darkening is a matter of opinion. It is important that the work should be done in a warm dry place, perfectly free from dust. In winter the work must be long enough in the room to become warm. If this is not done the polish will be *chilled* and dull.

Doors of cabinets, &c. should be taken off so as to be more easily handled, and as far as possible all work should be placed in a horizontal position, at such height as will allow easy working. Nail holes, cracks, &c. will often be found in re-polishing old work. These must be filled before going further with the job. A mixture of resin and beeswax or of ochre and wax used hot is generally used. Fine hard-wood saw-dust and glue also works well for the purpose. Any of these can be tinted to match the wood. Panels, if cracked, should be removed and a proper planed and glued joint made rather than stopping the crack with filling.

FRENCH POLISHING.

Staining. To darken the wood, or to bring the parts to the same shade, one of the stains given in the list at the end of this should be used. After preparing the stain as directed, wet a good-sized woollen rag with it, and go quickly over the surface of the wood in long even strokes in the same direction, not going twice over the same place and leaving none untouched, as it causes places of uneven colouring if any part has to be stained a second time.

Filling in. The pores of the wood must now be stopped to prevent the polish sinking in. There are several substances that will do this, but Plaster of Paris is most used and it must be of the finest quality. Make a pad of a rag rolled up, wet it and dip into the plaster, rub well so that it is forced into the pores. Remove all that remains on the surface before it sets, with a clean rag, and allow to dry. Another way is to mix the plaster with water to a thick cream and rub on—this is the quicker way of the two. Some workers use tallow and whiting, but this must be used hot. Melt the tallow and stir in fine whiting till pasty. Coloring matter may be added to any of these fillings. A filler that works very quickly and well is made by mixing whiting with linseed oil, adding a few drops of polish to it when on the rubber. In any case allow the filling to set before starting the next operation.

Smoothing. As the surface will now be rather rough and somewhat uneven at parts, it must be smoothed up with No. 1 glass paper or if necessary coarser first, then follow with No. 1. The best way to do this is with a piece of cork about one inch thick, the paper lapped round it so as to get a flat surface, and a good grip on the glass paper. This method is also a great saving of the paper. Any nail holes or small cracks may be stopped with a mixture of fine sawdust and glue applied hot, though this should be the first part of the work.

Oiling the surface with raw linseed oil comes next. A rag saturated with the oil must now be well rubbed over the work with plenty of friction, but what does not sink in must be wiped off to avoid leaving a greasy surface, rubbing well with a dry rag. Where whiting and oil are used for filling, the oiling up may be dispensed with as a rule, but much depends upon the wood worked upon, hard close grain wood requiring little or no filling.

Floating. Prepare a rubber by rolling some wadding to a ball, wet it with polish and cover with a clean soft cotton rag, pulling the corners to a bunch to hold by, and getting a smooth surface to rub with. A little oil is placed on the surface of the rubber with the finger, so as to enable the rubber to go smoothly over the surface, but the less oil used for this purpose, the better the finish will be. Rub in long strokes, and continue to do so, giving a fresh supply of polish to the rubber as often as may be required, till sufficient body has been worked upon it, then leave the work overnight to harden. On starting to work again the surface will be found not so smooth as was expected. Go over the surface with No. 0 glass paper, and the cork rubber till smooth and level. Some workers use pumice powder at this stage of the work, but its use should be avoided as far as possible ; it is, however, very useful in getting a smooth surface and filling any pores left unstopped. Wet the rubber as usual and sprinkle a little pumice powder on it (the powder had best be tied in a rag, so that a very small quantity can be shaken out of it) and go over the surface with this rubber. See that none remains on the surface. Having cleaned off all traces of the pumice or glass paper dust, the work is now ready for polish.

Polishing. Now proceed to get a good surface of polish, using the rubber as directed, but not using so large a quantity of polish, go over the work, rubbing a small part at the time with a circular motion till all the surface has been treated, and has a layer of polish thick enough. Special attention must be given to the corners of the work, as most of the rubbing is usually given to the middle of the surfaces, leaving corners and edges very thinly covered.

Spiriting off gives the finishing touch to the work, bringing all the surface to a uniform smoothness, and is done by partly dissolving the surface of the coat of polish already given; the spirit then evaporates and allows the coating to dry to a natural smooth surface. This operation is materially assisted by working in a hot room. It is at this stage of the work that dust is apt to do most damage. Damp a clean rubber with Methylated Spirits, using a few drops at the time, and go over the surface again, damping the pad as often as necessary, but avoid using much or it will loosen the layer of polish. The spirits should be in a bottle having a groove cut in the cork, so that a little can be dropped on the rubber without having to uncork the bottle each time. If too much oil is used during the polishing, as it will show as a greasy mark when the finger is drawn across the surface. Do not use any oil at the finishing if possible to avoid it, and of course none in spiriting off.

Final Brightness is obtained by using on the pad equal parts of polish, glaze, and spirits, rubbing lightly with the grain of the wood, and adding a few drops of glaze to the rubber when required. Work is often spoiled by using the pad too wet for the final rubbing.

Polishing Rubbers. To keep these soft and in good condition they should be stored in an air-tight tin canister. This not only prevents waste of the rubbers, but keeps them soft and ready at a moment's notice. It is also a great saving of polish, as a good deal is required to saturate the rubber before it is fit for use. Old rubbers are easier to handle than new ones (if they have not gone too hard through using) and work more freely.

Removing Old Polish. It is seldom advisable to do this, as the old polish forms a good base for the new coating, and saves the trouble of filling, &c. Usually it is enough to thoroughly clean the surface from grease, &c., by washing with soap and water containing a small quantity of washing soda; when dry, go over the surface with glass paper to get rid of scratches, &c. A saturated solution of soda or of pearlashes will quickly remove polish, &c., or for varnishes turpentine will do.

Rolled Polishing Pads are a great help in finishing polished work. These are made by rolling some woollen cloth strips one inch wide so as to form a flat cake, sewing the outer end. This gives a flat surface that cannot be got with wadding.

STAINING AND VARNISHING.

Staining. Wood intended to be either polished or varnished can be stained in a great variety of tints, but it should be remembered that all polishes and varnishes darken the wood somewhat, so that it should be allowed for in the staining. The colour can sometimes

be mixed with varnish, but it is seldom advisable to do so. The stain is best applied with a woollen rag well wetted with it, and it must be done quickly so as to avoid wetting the wood deeper than the mere surface. If it is desired not to stain the hands, it can be applied with a paint brush, but this method is not as handy as the rag. After staining, the work must dry thoroughly. It will then be found to have lost much of its smoothness, which must be restored by rubbing with glass-paper as much as may be necessary. This is most important, as it is impossible to get a good surface of varnish if the wood below it is rough. It is now necessary to size the work. This must be done whether it is stained or not. It is merely painted over with thin glue water. To make the size, soak some best glue overnight in cold water, pour off the water and melt the glue in a glue pot, then add three times the quantity of hot water and use while hot, painting it on the surface and avoiding bubbles and froth. Allow to dry overnight, and clean up with glass paper. The work is now ready for varnishing.

Varnishing. To get a good surface of varnish, the work must be free from dust and should be done in a warm room. The varnish must be laid on in long strokes in one direction, not crossing, and if found to be uneven or streaky, go over it at once with a brush nearly dry in the opposite or cross direction to the first coat. It is important to put the same quantity on each part to get an even coating, not thick at parts and thin at others. A very thin coat allowed to dry thoroughly, followed by a thicker one, will be found to give good results, but with a little practice one coat will be found to cover well and smoothly. The brush must be quite clean, and to keep it so should be well washed with spirits after using and wiped dry, or it may be kept in the bottle of varnish, the handle passing through the cork—this of course would apply only to small brushes in wide mouthed bottles. The brush must be of good quality, not so soft as camel hair nor so hard as a common paint brush. The best quality varnish brushes are ground off to a flat edge. All varnished work is improved by being allowed to dry in a warm room, and though it dries in a few hours, it gradually hardens for some weeks.

Varnishing Wall-Papers and Maps. This is done as in other classes of varnishing, first giving a coat of hot thin size, when quite dry varnish with the special paper varnish, which does well also for maps.

Fretwork and Carved Work must be varnished, as it is very difficult to apply the rubber to such surfaces. Fretwork should be cleaned up before cutting, and might with advantage be polished also while whole, instead of being varnished afterwards. Carved pieces or table legs may be treated with the rubber to get a body of polish on, and finished with a coat of varnish.

Gold Paint. The so called gold paint is a bronze powder mixed with a varnish, but the best effects are got by painting the work with an adhesive, and dusting the powder on to it. All that does not adhere being dusted off with a camel hair mop or a hare's foot, and used again. It is well to lay a large sheet of paper under the work to collect the powder. To prevent tarnishing, a coat of clear varnish may be given. Work so done will keep its colour for years.

The powder is best dusted on from a pepper box. Bronze powders can be had in 20 shades from silver color to deep gold, also copper, burnt copper, green and blue. For silver color use genuine Aluminium powder, which keeps its color, while silver colored bronze powder soon turns black. This is very much cheaper than buying the mixed gold paints.

Gold Leaf Gilding on flat surfaces is not difficult. Paint the required design with gold size or copal varnish and allow to partly dry, then while still sticky apply *Transfer Gold Leaf.* The gold will leave the surface of the paper to which it is stuck, and stick to the varnished places. Allow to dry thoroughly and dust off any superfluous gold. Silver and Aluminium leaf and imitation gold leaf can also be had. The Aluminium leaf keeps its color well, but silver leaf soon tarnishes. Imitation gold leaf looks well for a time, but soon tarnishes, so that if real gold is not used, the best substitute is good bronze powder varnished over.

Lacquering is a method of varnishing metal, used mostly to prevent burnished brass tarnishing. The metal is heated till a little too hot to handle, and the lacquer applied with a soft brush. Clear lacquer can be applied to silver which will then remain bright. Tinted lacquer can be had, which applied to polished tin makes it look like burnished brass, and only needs dusting to keep it so.

Repairing Broken Carvings, &c. The easiest way to do this is by making paste of fresh bread worked between the hands to a dough like putty, then adding a little copal varnish and working it up again. This paste is easily moulded or shaped with the fingers to replace the missing or broken part, and it becomes as hard as wood in a few weeks. A little coloring may be added so as to bring it to the color of the other parts. Although this composition is not as strong as the woodwork it is intended to replace, it will bear a fair amount of handling, but is more suitable for parts where not much strength is required. A stronger moulding paste is made with sawdust and glue, but it must be worked into shape while warm. It has the advantage of hardening quickly. For more intricate work such as replacing a carved panel, Plaster of Paris should be used. Make a mould by taking an impression of a similar panel with softened bread, and from this take a casting in Plaster of Paris, which, when thoroughly dry should be saturated with size painted on it till it will not absorb any more, then stain and varnish to match the other parts.

Transparent Varnish for Wood. This is usually a form of French polish made from bleached shellac and spirits laid on with a brush. The work must be sized with special size made from common isinglass or the palest gelatine. This varnish does not give so strong a coating as the colored lac varnished, and is mostly used for toys and small fancy goods such as are sold at seaside places, and have pictures of local views pasted on them before varnishing.

Fuming Oak is done to give the wood the appearance of age. The articles to be darkened are enclosed in an air-tight box, and with them is placed a saucer of the strongest Ammonia liquor until the fumes have brought the wood to the right colour. Staining is much easier and quite as effective.

Stencilled Designs. Panels, &c., of light colored wood are often ornamented (before varnishing or polishing) with suitable designs stencilled on. This is easy to do, the stencil cut out of special paper is either held or pinned to the work, and the stain applied with a stiff brush, which should be harder than a common paint brush, or an ordinary brush which has been cut down to half its length of bristles will do. The color is applied by dabbing, not by painting on in the usual way.

Sprinkled Designs are very effective. This process is the reverse of stencil work. Natural fern leaves or other articles of the required shape are laid or pinned on the panel. The brush is charged with color, and knocked against a stick held in the other hand, the result being a spray or shower of coloring fluid on the work. Cut paper patterns may be used, but natural leaves produce the best effect. It is an improvement to give a slight sprinkling after removing the leaves, so that the design does not appear too bare. After it is thoroughly dry, varnish with transparent varnish.

Floor Staining and Varnishing. Edges of flooring when stained are usually done with a stain and varnish combined. Two or three layers of which should be laid on to get a good thickness, so as to stand the necessary wear. It is advisable to size the wood first to economise the varnish. Where a pattern is required for the border, it should be stencilled on before sizing. Then deepen the color by going over the design with a paint brush. The varnish in this case should be clear enough to allow the stain to show through.

Transferring Pictures to Wood is a good method of ornamenting light color wood. The panel must be sized with a clear size, and given a coat of transparent varnish. The picture is placed face down upon it, being careful to avoid any place where there is no contact. The paper is best held by two opposite corners and allowed to touch first at the middle part, then the corners are lowered so as to gradually bring the whole surface in contact with the wood. Then press it down carefully, beginning at the middle and working round to the edges. This must be allowed to set till quite hard and dry, two or three days in a warm room if possible. When quite set, damp the back of the picture with a sponge, and allow the moisture to penetrate the paper, but avoid making it too wet. Now gradually remove the paper by rubbing a small part at the time with the finger so that bits of it curl up. Go slowly all over the picture and remove most of the paper, leaving only a thin film adhering to the varnish. Allow to become perfectly dry, then varnish with clear copal varnish or with transparent lac varnish as used for whitewood polish. The only advantage of this method of applying pictures is that the grain of the wood is seen through the lines of the picture. If the picture is merely stuck on the panel face upwards and afterwards sized and varnished with paper varnish, the effect is as good and the process much easier.

Antique Polish for Furniture. French polish has been used only about 150 years. The fashionable polish on furniture before that date was got by oiling the work with raw Linseed Oil and polishing ing well so as to drive part of the oil into the wood. Continual

polishing, assisted by a little beeswax and turpentine, gave a fine smooth polish. For oak furniture, plenty of friction and occasionally a little oil was all that was required to produce that beautiful though dull surface of the old oak furniture.

Leather Reviver. French Polish has long been used as a reviver for dark leather where it does not interfere with the color. After wiping off all dust with a damp rag, apply a little of the polish and rub moderately with a cloth. Old leather book covers are greatly improved with a coat of the polish, then well rubbed with a soft woollen cloth.

Paint Enamels. These can be made equal to those so much advertised by adding half the bulk of copal varnish to any good quality oil paint, but to get a smooth highly glazed surface the work must be smooth and clean. A coat of plain paint must be given first, and allowed to dry and set, then if necessary smoothed down with pumice before the varnish paint is applied.

White Enamel on Furniture. This is very effective for bedroom furniture or the woodwork of a drawing-room. Fill the pores with glue and whiting as directed previously; when dry rub smooth with a block of pumice stone ground to a flat surface by rubbing it on a level stone. The work has now to be sized. Mix a size by dissolving two ounces of common isinglass or fine gelatine in a pint of boiling water, add to this two ounces of flake white and mix well until smooth. Apply this while hot with a brush or small sponge. When dry give a second coat, and rub it down to a smooth surface with a rubber of thick felt or woollen cloth, using pumice powder and a little water. When quite smooth proceed to polish it the usual way, but *without oil*, using the special transparent polish as used for light colored wood.

STAINS, VARNISHES, &c.

Home-made Polish, Varnish, &c., is seldom satisfactory, most of them being difficult to make on a small scale, and in many cases the materials cannot be bought in small quantities. The composition of some of the best polishes and varnishes are trade secrets.

French Polish. No. 1—2 ounces of fine Orange Shellac, ½-ounce Gum Sandrac, put in a bottle and add 1 pint Methylated Spirits (strongest). Cork and put aside till dissolved, shake occasionally and keep the bottle well corked. No. 2 -To make a cheaper French polish, use 4 ounces Shellac to 1 pint spirits.

Glaze to finish with, dissolve 8 ounces of Gum Benzoin in 1 pint Methylated Spirits, then strain and use to mix with the polish for final coat.

Tinted French Polishes. For Black add 1 oz. of Lampblack to each pint. For Red add 1 oz. Dragon's Blood. For other shades use Ochre, Vandyke Brown, &c. For delicate tints use the Aniline Colors. For Transparent Polish and all the light shades make up with Bleached Shellac, which should be crushed small before it is put into the bottle. It should be bought just as required as it does not keep well.

To Darken Mahogany. Dissolve 1 oz. Chromate of Potash in 1 pint of water, boil and allow to cool, apply with a rag.

Brown Stains. 1—Dissolve 1 oz. Vandyke Brown powder in 1 pint water, add 1 oz. Pearlash, boil the mixture and apply while hot. 2—Strong Coffee is a simple and effective stain for wood, and in fact for most substances. 3—Dissolve 1 teaspoonful of Per-Manganate of Potash in ¼-pint of water. This makes an excellent stain and is also useful as a disinfectant and deodoriser.

To Bleach Wood. Add a little water to ordinary Chloride of Lime or Bleaching Powder to reduce it to a cream. Apply with a brush to the work, and allow to remain say two hours, wash off and dry the work. If not white enough, apply another coating.

Black or Ebonised Work. Most black stains are forms of ordinary ink. The following will be found useful. 1—Wash the work with a strong solution of Sulphate of Iron (Green Copperas) two or three times, allow to dry. This will give it a brown tint. Now wash with water in which Logwood chips have been boiled, this will turn the brown tint to black, or nut galls may be used in place of the logwood. Another form of this stain is to add some solution of Sulphate of Iron to some used pyro photo developer, which also produces a black ink. 3—Fill the grain with glue to which some lamp-black has been added. When dry, smooth with glass paper, and polish or varnish with French Polish to which lamp-black has been added. The lamp-black is easily made by holding a sheet of metal close over a gas or lamp flame, so that soot is deposited on it.

Brushes. For Oil Varnishes, such as Copal, use a soft bristle brush, which may be cleaned with turpentine. For Spirit Varnishes such as Shellac in Spirits, apply with a soft brush such as a Goat hair, or so called Badger or Camel hair brush, which may be cleaned with spirits.

Polishing Paste. A good finish may be got on French polished work with the following paste :—3 oz. white wax, shave it thin with a knife, and dissolve in ½-pint of turpentine. Take ½-oz. Castile Soap (common soap will not do) cut in thin slices and boil down with ½-pint water. When cold mix the two solutions and stir well. Use with a rag and polish with a soft woollen cloth.

BRASS HANDLES AND OTHER FITTINGS.

When re-polishing cabinet work, the handles, key escutcheons, &c., should have attention. In the best work, especially antique French cabinets, these were gilded, and should be electro-gilt, but when it is not desirable to go to much expense they should be cleaned up and lacquered. Remove all old lacquer by washing with a scouring soap (Monkey Brand does well for this) using a brush and warm water. When clean dip for a second or two in *dilute* Nitric Acid (1 part of acid to 2 of water), then at once rinse well in clean water and dry in hot boxwood sawdust or in a hot oven. While still hot apply lacquer with a soft brush. French Polish made with bleached shellac does very well for this purpose.

COPYRIGHT.

CYCLE BRAZING

By M. COLE.

* * * * * *

Most of the parts of a Cycle Frame are united by Brazing, and the method may be classed under three heads—

Where a Tube is Brazed to a Bracket or other Forging.
Where a Tube is Brazed to another Tube.
Where a broken Tube is Repaired by Brazing.

In all these cases the proceedure is on much the same lines:— *1—Clean the parts. 2—Fit them together. 3—Apply the Flux and Spelter. Cover the work to keep in the heat. 5—Apply the heat. 6—Clean the joint.*

1—**Clean the Parts.** To make an effective joint the parts must be clean. They may be filed or cleaned with emery cloth according to their condition, and this should be done immediately before making the joint. Some blacklead made into a paste with water must be brushed on to the threads of the bottom bracket to protect them from the heat and dirt.

2—**Fit the Parts to be Joined.** To make a safe joint the parts must be a perfect fit, no hollows to be filled with the spelter should ever be left. The spelter will flow into a well fitting joint better than a loose one. There is a kind of sucking action that is not present in a loose joint. In many cases it is advisable to fasten the parts together by a hole drilled through the intended joint, and a bit of iron-wire rivetted through. Other joints may be tied with soft iron binding wire. If the parts can move, even in the slightest degree, a good joint is impossible. It should be remembered that the tubes soften with the heat, and if the frame has not been properly supported it will, while hot, bend with its own weight. It is advisable to begin brazing at the back chain stays, and see that all parts are perfectly true and parallel before making joints. When a broken tube is mended a liner should be inserted, this may be either solid or hollow, but must be a good fit; in other cases a sleeve may be put over the broken part.

3.—**Apply the Flux and Spelter.** The flux is usually borax. The spelter is a special brass that will melt at a low temperature, and is in the form of either fine or coarse grains, or as wire or rod, or several strands of brazing wire twisted together, which is easier to handle than rod spelter. It should be frequently dipped in Borax so as to supply plenty to the joint. Where practicable mix the fine grain spelter with borax powder and water to a paste, and put inside the tube, so that it will flow into the joint, a little more borax

paste may be put outside the joint to keep it clean by protecting it from the flame. Where not practicable to put inside, put the paste of borax and spelter round the joint. In brazing a closed tube, a small hole should be drilled above the joint to let the gasses escape. In some jobs it is better to put several layers of brazing wire round the joint, twisting the ends so as to get close contact, and a couple of rows of binding wire over all, then plenty of borax paste, which the wire will help to hold on. Some of the best work is done with a rod of spelter held to the joint when hot enough, moving it along as the end melts—this method requires considerable practice to do well. Small joints may with advantage be made with silver-solder, which makes a very strong joint, is easy to use, very clean and cheap; as the quantity of silver-solder required is very small. It works at a lower heat than spelter, so is specially useful when making a joint near a brazed joint. It is used in the same manner as spelter, and is specially useful for Racing Machines where light weight is important.

4.—Cover the work to keep in the heat. In order to prevent waste of fuel and time, it is necessary to cover the joint with some material that bear a great heat without giving off any fumes or gas, or in any way affecting the job. Coke is sometimes used but does not make a clean job. Asbestos-cubes are now accepted as the best, cleanest, and cheapest, 3-lbs. being enough for ordinary work—they are composed of a mixture of asbestos and fire-clay.. a layer of these should be put under and a heap above the joint. A better way is to put a fire-clay slab under the work, and another at the back (upright) so that the flame that does not directly strike the work is thrown back on to it by the back slab. The cubes should also be used to cover. A sheet-iron table should be made to put the work on for brazing.

5.—Apply the Heat. The most important thing to remember is that the heat should be so applied that the whole joint is heated equally, and the spelter melted by the heat of the parts to be joined, *not melted by direct heat.* The heat must therefore be applied to the thickest part first, and gradually extended, never starting at the thin part. The parts to be brazed must be heated till hot enough for the brass to form an alloy with the surface of the steel, and not heated higher or there is a risk of burning the steel. The whole art of brazing lies in being able to judge this, and it can only be acquired by practice. Do not keep the job hot longer than is necessary to make the joint; the moment that is done, turn off the gas, and cool by the blow.pipe blast. The heat should be gentle at first, and this will drive off the water added to the borax, which will then part with its water of crystilization, and form a kind of glass—full heat may then be turned on as directed above. The spelter should commence to flow nearest the joint first. If the outer layer is the first to melt, it is due to not applying the heat correctly. If the spelter is inside the tube it will be seen to work its way through, a few light taps on the joints will help it at this stage. Once the full heat is turned on it must be kept up till the job is complete or it will spoil. A good help is to practice brazing brass articles. The melting point of the spelter is so little

below that of sheet or tube brass, that when able to braze brass you should have no difficulty with steel. Don't try to learn cycle-brazing on the frame of an expensive machine.

The sources of heat are:—*Smith's Hearth, Gas Blow-pipe, Oil or Spirit Torch, and Hot Tongs.*

Smith's Hearth is the oldest source of heat for brazing, but the heat cannot be regulated, and frequently one side of the joint is burned, while the other is not hot enough.

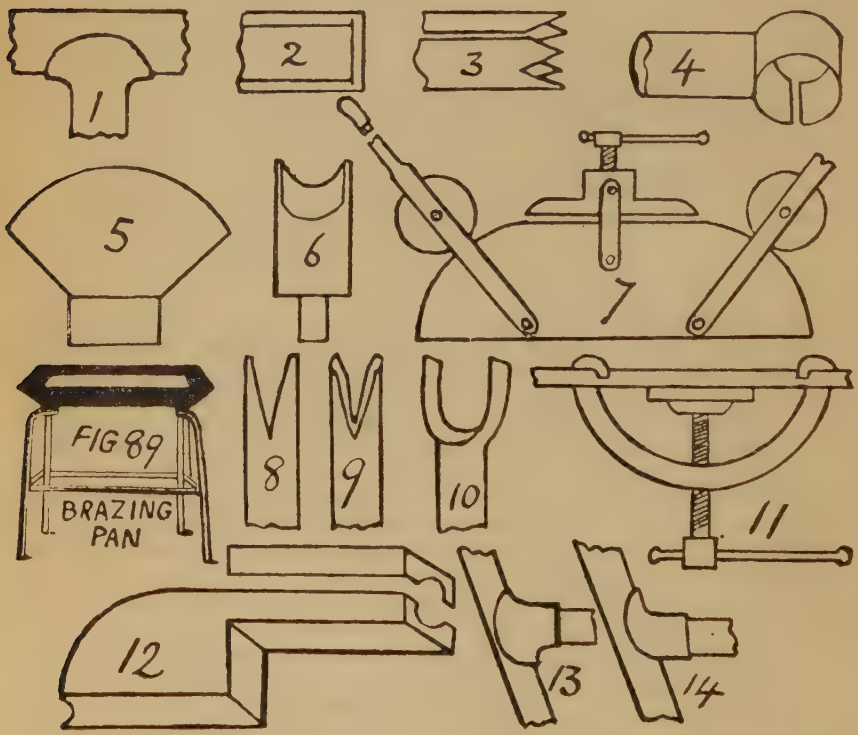
Gas Blow-pipe is the most convenient and cleanest source of heat, as it can be applied exactly to the required spot, and so avoid over-heating the other parts. A double action foot-bellows is required for this (single action being useless). A good deal of misapprehension exists as to the size required. In an ordinary gas burner the air required to form a flame is supplied to the outside of the flame with the result that the gas is only partly burned, and a lot of soot formed by the carbon that is unable to burn for want of air. In a blow-pipe the air is forced into the middle of the flame. If the right quantity is suppled all the gas will be properly burned, but if too much the excess of air will cool the flame. The pressure of air also enables the worker to direct the flame in any required direction. Most workers make the mistake of using too much air. The quantity of air delivered by $\frac{3}{16}$in. aperture requires all the gas supplied by $\frac{1}{2}$ in. gas-pipe if near the meter and at a good pressure, (if at a distance larger should be used), but the tap on the supply pipe must be larger than the nominal size of pipe. The bore in the plug of a gas-tap is so much smaller than the nominal that only about half the quantity of gas passes through that should do, so that a $\frac{3}{8}$in. pipe must have a $\frac{1}{2}$in. tap—a gas blow-pipe of $\frac{3}{16}$in. air tube and $\frac{1}{2}$in. gas tube will be correct size for the above arrangement. Nothing is gained by a larger size, as it must be throttled down to these sizes. It is useless attempting to braze with less than $\frac{1}{2}$in. gas supply fitted $\frac{1}{2}$in. clear way tap. Sufficient air must be supplied to enable the gas to be burned without smoke or soot; if more air is used the flame will be starved, giving a large flame of very low efficiency. It is always advisable to have an assistant to work the blower (a lad could do it) so that the skilled workman can give all his attention to making the joint, which he certainly cannot do if working a foot-blower at the same time. It should also be remembered that by working the blower at double the speed, double the quantity of air is delivered, thus enabling a smaller blower to be used. To get the best effects with any foot-bellows, they should be bolted down on a working bench and worked by hand. This method gives double the efficiency as compared with foot pedalling. Where a great deal of work is done, a larger bellows worked by hand and 1-in. gas supply will be required.

Oil or Spirit Torch is a modification of the gas blow-pipe, and is very useful where no supply of gas can be had, but care must be used to select one that is suitable for the work—those that convert the paraffin or benzoline into an oil gas are the most reliable and cleanest, and, as they do not require bellows, are really cheaper as well as much more suitable than those using a spray of oil and bellows.

Hot Tongs are useful for repairing a broken tube. They are like blacksmith's tongs, but very heavy at the ends, which are hollowed to a larger size than the tube to be brazed. When the joint is prepared in the usual way, the tongs are made white hot at the ends and clasped on the joint; the heat is sufficient to melt the spelter, but as in other methods care must be taken not to burn the tubes.

6. Cleaning the Joint. While still hot the joint should be cleaned with a brush of steel wire made for the purpose.

For quick repairs the tube may be painted over with a varnish composed of best black oil paint, as sold in tubes for artists' use, to which is added a little copal varnish. This dries quickly and is as glossy as a japanned surface—with a little care brush marks can be avoided.



Preparing Joints for Brazing.

1.—Half-lap joint. 2.—Closing end of a tube. 3.—Best form of liner. 4.—T Lug for handle bar. 5.—Bending Block. 6.—Section of same. 7.—Bending Block for handle bars. 8-9-10.—Method of opening tube to make lap joint. 11.—Screw Bending Cramp. 12.—Bending Block (hard wood). 13.—Strong Angle Joint. 14.—Easier form, but weaker.

COPYRIGHT

Cycle Enamelling.

By M. COLE.

* * * * * *

The Protective Coating given to Cycle Frames is usually spoken of as Enamel ; it is, however, really japan.

Clean the Work. All surfaces to be enamelled must be not only perfectly smooth, but absolutely clean and without a trace of grease ; even touching the work with the bare hand after cleaning must be avoided. The cleaning is best done with emery cloth, and fine pumice-powder and water. Clean cloths should be used whenever the work has to be handled, and lifting done with metal hooks.

The frame must be carefully examined for any roughness due to brazing or rust, and such parts must be cleaned and smoothed with a fine file and then thoroughly polished with emery cloth before applying the Varnish.

Protect the Parts that are to be free from enamel. The method of doing this depends on the shape of the parts. Holes may be fitted with cork or wood plugs. Screw-threads covered with string, coated with wet clay, or smeared with a paste of whiting and water.

Apply a coat of Priming. Some workers use the same Varnish for the first coat that is used for the succeeding ones, but a much better body is got by using a Special Priming. It is applied with a soft brush, very evenly, working in one direction, not putting on so much as will run, yet being careful that all parts are well covered. This applies also to the coats of enamel which follow.

Stove the Priming. The Frame must now be lifted with metal hooks and hung by them in the stove. The heat of the stove must be raised to 300° F., and kept at that heat for one hour. The work must then be removed for the enamel coats. The frame should now be examined for any places where there is undue thickness or thinness of the first coating. Lumps can be rubbed down with pumice-stone, but any parts too thin should have a little priming applied to the place and stoved again.

Apply the Enamel. The work being cooled, the enamel may now be applied carefully and very evenly with a suitable brush. Raise the heat of the stove to about 120° F., and then put in the work. Increase the heat gradually so that it rises to 220° F. at the end of the first hour, then raise quickly to 400° F. and keep at that one-and-a-quarter hours. When cold, smooth with fine pumice powder and water, so as to leave an even and smooth surface for the second coat, handling the frame carefully so that no dirt gets on it.

Second Coat of Enamel is put on in the same manner as the first coat, but leave it in the heat half-hour longer. Total time for the two coats: five hours. The work when cool is ready for packing —if no gilding or transfers have to be put on—and should be at once lapped with strips of fine tissue paper, lapped round the tubes, with brown paper outside that so as to protect the frame while the parts are fitted on to it. Best work often receives three or four coats and

a good polishing between each of them, but for cheap work as a rule only one coat each of priming and finish are given.

Wheel and Gear Case Enamelling. Gear Cases having parts put together with soft solder, cannot be stoved at a temperature used for ordinary enamel ; some builds of wheels are also soldered at the crossing of the spokes. It is therefore necessary to use a varnish that will stove at a low heat, as the heat required to stove the ordinary finishing coat enamel is much higher than the melting point of soft solder. A special varnish is made for this purpose called *Gear Case Enamel.* It is stoved at a very low heat, 220°F. to 240° F., and has a very brilliant finish, but there is the disadvantage that it is very soft, so that it is soon scratched and loses its brightness. The higher the stoving heat of varnish, the harder and more durable it is when stoved.

When a large quantity of work is done, the usual plan is to dip in a Vat of varnish and allow the surplus to drain off, but unless very skilfully done the effect is not so good as when the varnish is painted on. For the priming, the work may be laid in a shallow tray and the priming poured over the frame with a ladle. The tray must have a cover to keep out the dust. In all cases the varnish must be well stirred before using, as the heavy part is apt to sink. The stock of varnish should be kept in stoppered cans, and care used to prevent any dirt getting into it.

Re-enamelling Old Work. When the old enamel is of good quality and is in fair condition, it may be used as a base for a new coat. If so, carefrlly clean off all grease by washing with a strong lye made of pearl-ash and water, then swill off and clean thoroughly with powdered pumice-stone and water ; the coat of enamel may then be given. If badly chipped at any part, a coat of enamel may be given to that part only, then smooth over with a piece of pumice-stone, which must be kept at a level surface by rubbing, when required, on a piece of stone. If a thoroughly good job is to be made, the old enamel must be burned off—using a Gas Burner, or a Gas Blow-pipe. Some special burners are made for this purpose.

As the enamel hardens with age, it is sometimes necessary to scrape it off. For this purpose a good scraper can be made from an old saw file of triangular section, or *three-square* as they are usually called. The sides are ground smooth on a grind-stone or emery wheel, thus leaving sharp edges. As these tools are of good steel, they will keep an edge better than a tool made from low quality steel. They should not be annealed, but left hard.

A frame in which the enamel is much chipped will usually be found to be rusted at those parts. It is advisable to carefully examine such before quoting price for re-enamelling, as there is much extra work entailed.

The temperature and time for stoving will vary with the different makes of priming and varnish used, but purchasers should insist on having the correct heat required stated on the label of each can they buy, and work strictly in accordance with instructions given.

It is most important to remember that a very small quantity of dust will spoil the work ; in fact the principle difficulty is to ensure absolute freedom from dust.

It is impossible to keep the whole of the oven at the same heat—the top being always the hottest (except the floor just where the heat is applied, but as no work is placed just there it may be disregarded). The effect of the greater heat on the work at the top is that the enamel flows more freely and comes to a better surface, so that, in practice, it is advisable to place those parts most seen nearest the top of the oven ; and in reading the thermometer this must also be taken into account.

The Oven. Any box that will keep in the heat and keep out the dust will do for an oven, provided it will stand the heat required, but obviously a specially built oven is necessary if the work is to be properly done. A great variety of materials are possible for the purpose, but the most suitable are *Brickwork* or *Sheet-Iron.*

Brickwork Oven. This need not be more than 4½ ins. thick, and may with advantage be built in one corner of a cellar, having a stone or brick floor, so that two sides only need be built. In any case it is well to arrange to put the work in at the top—a cover of sheet iron must be made to fit on top. A brick oven should be lined with sheet metal, the thinnest tinplate will do, as it is only as a protection from dust.

Sheet-Iron Oven. This may with advantage be built of corrugated sheets, joined so as to be practically air-tight. The sides must be double, having an air space of at least 4 ins. between, otherwise a great deal of fuel will be wasted. Some prefer to pack the space with slag-wool, or other non-condcctor, but the air space mentioned will be sufficient to keep in the heat, as a layer of air is as bad a conductor of heat as the same space of almost any heat insulater, provided the hot air is not allowed to escape. A double lid as described must be made for top of oven. The size of the oven will depend on the amount of trade likely to be done. If a fair amount is expected, the oven should be large enough to take a tricycle or tandem frame. At the same time it must be remembered that the larger the oven, the greater the amount of gas used, even if only a small article is being stoved. The oven lid should have a suitable ventilator (which can be partially or entirely closed when required) so as to allow the fumes to escape. This is important, as the fumes, if confined to the oven will tarnish the work.

Another shape of oven and one easier to build, is of sheet-iron, which should be galvanised, as black iron is very liable to rust, and some of the rust is sure to get on the work and spoil it. For a small oven it may be built single, without the air chamber. This will be found quite as effective as a double oven for a small size. The door should in this case be in front and not hinged, but made to lift off.

Gas—The Source of Heat may be either gas or paraffin oil. Gas is, of course, the most convenient and reliable. A small oven, such as would hold three bicycle frames, would measure 4ft. 6in. high by 3 ft. long and 18 in. wide, inside measure. To heat this two burners will be required, though the same burners will heat a stove one-half larger. The burners are 24 in. long over all, and require for the two a gas supply of at least ½-in. if the pressure is good. It is, however, an advantage to have a ¾-in. supply, so as to leave a margin

for possible extension. The same supply does also for brazing. It should be remembered that the pressure of gas is much less during the daytime than at night. The gas burners can be placed inside the oven near the bottom. The body of the oven must be raised on legs say twelve inches from the ground. A hole must be provided at the top to allow the thermometer to be inserted, this is the right place for it, not as usually fixed—in the door.

Oil Oven. This is built in a similar form to the gas oven, but a false bottom must be fixed about 4 in. from the bottom of the oven, and a short pipe 2 in. diameter led from the outside to under the false bottom. A self-acting petroleum torch is placed near the oven so that the flame from it enters the tube and passes through it to the underside of the false bottom. This will be found quite as effective as gas, and the same torch will do for brazing. The introduction of this torch places cycle enamelling within the reach of many cycle builders, who from want of gas supply were formerly unable to do their own enamelling.

The Thermometer. A reliable thermometer must be used. It should be fitted in a brass tube, with a little Asbestos-fibre at the bottom to protect the bulb, which is of very thin glass, however thick the stem may be. The tube should have a flange on it about two-thirds up—which rest on the edges of the hole in the top of the oven. The upper part of the tube is cut away at the front to allow the scale to be seen—this style will be found much less liable to breakage than the bent form. As the heat of the oven goes up to 400° F., the thermometer should be graduated to 600° F., or in case of an accidental rise in temperature it will burst. From a mistaken notion of economy, some workers have tried to do enamelling without a thermometer, but this small saving has always resulted in spoiled work.

Transfers. Apply some good copal varnish very thinly, but evenly, to the transfer, when partly dry and sticky apply to the frame, rub down gently, starting at the middle to get rid of air-bubbles, allow to set a few minutes, then apply a piece of thick blotting paper well wetted, and allow the moisture to sink in. When the back of the transfer is thoroughly wet, the paper can be easily removed. Stove for a few minutes at 180° F., then remove, varnish and stove again—same heat twenty minutes.

Gilding on Cycle Frames. For Gold Lines, Names, &c., paint where required with gold size, using a fine camel-hair brush, when the size is partly dry (tacky) apply gold-leaf, cutting gold and paper into strips and using the paper to place the leaf into position, rub the back of the paper slightly so that the gold sticks, remove paper and allow to set. When quite set varnish over with good clear copal varnish, and stove at a very low heat, say 150° F.

The gold leaf used should be the *Transfer Leaf*. This is lightly stuck to paper, and so there is no danger of the leaf being blown away while being applied. The gold readily leaves the paper and adheres to the prepared work.

COPYRIGHT

Pneumatic Tyre Repairing.

By M. COLE.

* * * * *

INDIA RUBBER WORKING.

India Rubber in its pure or "native" state has very little elasticity. It can be dissolved in mineral naphtha, or in benzoline, or what is most suitable in bi-sulphide of carbon. When the rubber is made into a paste with one of the above solvents and a suitable proportion of sulphur, it comes from the machine in a sheet and is known as *mixed sheet*, and if put in a mould and subjected to suitable heat, it undergoes a chemical change and becomes *cured or vulcanised rubber*, and is no longer affected by any moderate changes of temperature. The proportion of sulphur, and the heat at which the mixture is cured, determine the varying properties of the resulting vulcanised rubber, from very soft and elastic as in inner tubes, to the hard vulcanite. Pure, or native rubber, has the peculiar property that if freshly cut surfaces are brought into contact they unite strongly. This is the principle on which rubber cement or solution depends. It is native rubber that has been torn into small fragments in the presence of a large quantity of water to wash out the impurities, and delivered from the machine as a sheet called *masticated* rubber. This is then dissolved in a suitable solvent, and forms the *rubber solution*. When some of the solution is smeared on two surfaces of canvas, and allowed to stand until they become surface dry, the solvent has then evaporated, and left a film of pure rubber on the canvas. If the surfaces are now brought together, and into intimate contact, so as to expel all air from between them, the surfaces unite. This method can only give a joint as strong as the rubber used in it. As this is pure rubber, it is much weaker than vulcanised rubber would be, so that for making a cycle tyre cover it is necessary to use a paste containing sulphur, and to put the canvas and its cover of mixed sheet into a mould and vulcanise it, while in repairs we have to be satisfied with another method known as *cold curing*. In this method, by blending sulphur, &c. in *a suitable form* with the rubber solution, a vulcanising process goes on slowly and gradually cures the film, or it can be cured at a very low heat, say 100° F. or 110° F., about the heat in the sun on a very hot day. It is impossible to make a good joint with bad solution. The solution should be nearly as thick as treacle, not as in many cases as thin as olive oil. The surfaces to be joined must be free from dirt and grease of any kind. When joining rubber surfaces they must be scraped or cleaned with glass paper, and all surfaces should be cleaned with benzoline to make sure they are free from grease. When working on canvas, two or even three coats of solution should be given, each well rubbed in so as to get strong keys or ties, and each allowed to become quite

dry before the next one is put on. There is no tool invented that will do this so well as the fingers. The solution method is the best way to join vulcanised rubber, but the only way to make a *perfect* joint between two rubber surfaces is to join them in the *mixed sheet* and then vulcanise the entire article in a mould. This is done in all mechanical rubber goods, and the joint so made is as strong as the other parts. For this reason tyre covers or non-slipping strips that have been joined after vulcanising should not be used.

CAUSES OF FAILURE AND BREAKDOWN.

Low Quality of Rubber. Some of the low priced goods are made from inferior rubber, and cannot possibly stand the wear to which a tyre is subjected. **Cured at too high or too low a temperature.** The first of these causes the rubber to be brittle, the second makes it soft and wanting in elasticity. **Faulty Design,** causing the edges of the rim to cut the cover. **Using Tyre not fully pumped up.** This is the cause of failure in many well made tyres, and is enough to ruin the best tyre ever made. The inner tube chafes against the canvas lining of cover, which soon rubs weak places in it. **Not using the machine.** This is a frequent cause of tyre failure :—the only way to keep any article of rubber in good condition is to use it.

Inner Tube too small. The failure of inner tubes can usually be traced to their being too small. The tube when inflated just enough to fill it without pressure should be quite as large as it is to be when in use. If smaller it will be stretched when in its place and pumped up, and the effect of such stretching is easily seen by stretching a bit of sheet rubber and puncturing it with a pin, compare the hole so made with another made by the same pin in the same piece when not stretched. In fact a pin prick in an inner tube that is not stretched *will, if slanting, close itself.*

The only duty of the inner tube is to hold air ; that of the outer tube, formed of the rim and cover, is to protect the inner tube, so that *the cover need not be air-tight*, and in any repairs this should be remembered. Many workers have the idea that the rubber solution used to cement two surfaces should be sticky or tacky when put together. Sticky surfaces make a weaker joint, but in many cases, as when adjustment is required after bringing the surfaces together, there is no choice about the matter.

Locating Punctures. This is usually done by removing the inner tube from the wheel, then pumping up with slight pressure. By bringing each part in turn under the surface of water, bubbles on the surface of the tube will show where the air is escaping. A mark should at once be made with a copying ink pencil.

Patch on Air Tube. Both the patch and the place it is to cover must be quite clean and, in particular, free from grease. To make sure of this, both surfaces should be washed with benzoline, and be rubbed with glasspaper. The surfaces are then both covered with solution well rubbed on, and allowed to become quite surface dry. The patch must be placed on the tube so that there is no stretch in either of them, then press it firmly down. For quick repairs, when there is no time for the surfaces to dry, they may be warmed, as the

solvent evaporates at a low heat. When finished sprinkle a little French chalk powder over the job to prevent any solution outside the patch sticking to the cover ; a bit of thin paper may be placed on it instead.

Joining the Ends of Air Tube. Having thoroughly cleaned the parts to be joined, turn one end inside out for the length of the intended joint. Give a coat of solution to each and allow to dry. Then give another coat, and when the second is dry, bring the ends together and slip the turned over part gradually over the other end, turning it over to its right place a little at the time. As some practice is required to do this well, the turning over may be done while the second coat is still wet, as this allows a little adjustment to be made. In this case the joint should be warmed for a time to drive off the solvent. If the tube is not fully long enough to make the joint, it is advisable to put a separate piece on, and put the two ends into it. This is the easiest and best way to join a tube.

Porous Inner Tubes. The inner tube is sometimes porous, from bad quality of rubber used or other cause, and will not hold air at pressure. This is incurable, and it should be replaced at the earliest opportunity. It will be found that porous tubes are usually too small for the wheel, and it seldom occurs in one that is large enough to be pumped up without stretching.

New Rubber Outer Cover on Old Tyre. First strip off the old cover. Thoroughly clean both the canvas and the under side of the new cover, especially the latter. If you have no block to work on, put the air tube in position on the rim and the cover over it, but with the edges outside instead of inside, so that the whole of the canvas can be got at. Adjust the cover carefully and inflate moderately hard. This will hold the cover in position firmly enough to allow the work to be properly done. Coat both the canvas and the rubber thinly with solution, rubbing well in, especially the canvas. Allow both to dry, then give another coat to each. As in this case it is impossible to get the cover exactly right at the first contact, the last coat of solution must *not be dry*. This is a drawback, but it cannot be avoided, as if the surfaces are dry there is no possibility of making the adjustment. The rubber may then be put on the canvas and adjusted.

Joining the Ends of Rubber Covers. The ends must be bevelled off, the bevel being not less than $\frac{3}{4}$ in. long. As this is difficult to cut, the best way is to wear it off on a *grindstone*. When the rubber strip is not long enough to make a joint of this sort, it should not be used, as a butt joint cannot be relied upon.

Cut Outer Cover. This is usually the result of wilful damage. The cut should be sewn on the under side with stout thread, as used for carpet making. Avoid using thinner thread as it is liable to cut. Put the stitches so as to avoid such strain as would tear the tyre at other places. The edges of the cut must be solutioned before starting. In such repairs it is seldom necessary to do anything to the rubber surface of the cover, but a patch of canvas must be stuck on inside the cover, over the stitching, to prevent the threads chafing the inner tube.

Piecing the Outer Cover. The rubber must be loosened from the fabric round where the repair is to be done, and a piece of rubber cut out in such manner that both ends are bevelled. The new piece having been cut to an exact fit is solutioned and inserted in its place. When only a small piece is to be replaced, loosen the rubber round the hole, and with a sharp knife cut out the bad piece so that the hole is much larger at the bottom than at the surface. Then cut a piece to exactly fit this, and fix it in place with solution.

Vulcanising a Patch on Outer Cover. This is less difficult than is generally supposed, but some special appliances are required. A metal block the shape of the inside of the tyre, capable of being heated either by gas or steam. For gas heating the flame acts on the under side of it, if heated by steam it must be hollow and steam tight, and connected to high pressure steam boiler (only a very small one is needed). The heat of steam is proportionate to the pressure, and about 75 lbs. per square in. gives the right heat for vulcanising, so that it is necessary to have a pressure gauge attached to the heating tube. If gas is used a thermometer graduated to at least 400° F., preferably 600° F., must be used. The cover is placed between the heating tube and a curved metal plate the shape and design of the outer surface of the tyre, and cramped together by suitable means. The bad part of the rubber covering it is intended to replace is cut away, and the surfaces carefully cleaned with benzoline or petrol to ensure freedom from grease. A piece of "**Mixed Sheet Rubber,**" *no other sort will do,* is cut to fit the place where the patch is required. As the mixed sheet is thin, as many layers as are required are placed in position, and the metal parts cramped together. Heat is now applied and the whole got up to 290° F. to 300° F. according to the brand of rubber used. Keep at that heat say 15 minutes after the blocks are heated through. The rubber will soften with the heat, and then a chemical change called vulcanising or curing takes place. When it is certain that this has occurred all through the substance of the patch, there is nothing gained by continuing the heat. The cramp should be screwed tighter while hot. Most tyres have a raised design on the tread. To re-produce this design on the patch, a mould must be made from a good part of the tyre, using three parts of finest Plaster of Paris to one of powdered French Chalk. Mix with enough water to make a thin cream, and having placed something at the sides to prevent overflowing, pour on enough to make about 1½ in. thickness. Allow to set say quarter hour, then remove and put in hot oven until all trace of moisture has gone. This is used in the vulcanising press with a plate of suitable shape. To prevent adhesion of the plaster to the tyre when making the cast, the tyre should be well greased with *Castor Oil*, which is the only oil that has no bad effect on rubber. A good layer of soft soap or of vaseline is used by some workers.

Rubber Solution that can be Vulcanised is made by mixing finest *Flowers of Sulphur* with any good make of ordinary solution, 10 % to 25 % according to purpose required. If the bad place has a little of this rubbed well into the texture of the canvas it will ensure the mixed sheet getting a good grip.

COPYRIGHT

Mending and Repairing.

By M. COLE.

* * * *

CEMENTS.

1—**Flour Paste.** One of the best adhesives. To be good it must be very carefully made, and as clean as if required for food. Put a quantity of best flour in a basin, allow cold water to flow on it slowly, stirring all the time, until it becomes first a thick dough, then a thin batter, add cold water till it is like a thick cream and perfectly free from lumps. Place in a clean pan and heat till it changes color, stirring it all the while or it will stick to the bottom of the pan and be burned. This thick paste keeps better than thin, and can be thinned by adding water. For many purposes a very thick paste is best.

2—**Shoemaker's Paste** is made as above, but using Rye flour instead of Wheat flour, and is a strong adhesive, and less likely to turn sour. This can be bought ready made at most grindery shops.

3—**Paste made with Glue.** Glue is supposed to increase the adhesive power of paste. Soak good glue overnight in cold water, strain off the water, and add the glue to the paste while hot, in proportion of ¼-lb. glue to 2 lbs. flour. To get the benefit of the glue this paste should be used hot.

4—**Preservatives for Paste, &c.** To prevent paste turning sour or mouldy and to keep the flies away from it, add while making, 10 grains of Per Chloride of Mercury to each quart of paste. This gives the paste the power of adhering to bright metal surfaces, but the preservative is very poisonous. Another preservative is 10 grains of Crystals of Phenol (Carbolic Acid) to 1 quart, or a few cloves may be put in the paste, and boiled with it.

5—**Starch as Paste.** Flour paste owes its adhesive power to the starch it contains. Ordinary starch answers as well, and is better for sticking paper to glass. To prepare it, mix ordinary starch with cold water, and heat as in making ordinary paste, or blend with just enough cold water to thoroughly moisten it, and add boiling water, stirring all the time until it thickens. Starch does not keep so well as flour paste, so should be made fresh when required. All forms of paste are best applied with the finger if thick, and rubbed well into the texture of the material to be joined. For large surfaces the paste must be thinned and used with a brush, but always using it as thick as possible, as there is then less expansion of the paper, &c.

6—**Gum Arabic.** When this is used it must be of good quality, the low qualities do not stick well and are no saving. Place in a bottle and add cold water to cover it, allow to stand until dissolved, then strain. When using, it is best to apply the gum to a piece of wood—then touch the gummed surface with the paper to be joined.

7—**Dextrine Paste.** Dextrine or British gum is an artificial gum made from starch, but it has not the holding power of either gum or paste. It is, however, a very convenient form of adhesive as it only requires to be mixed with a little cold water, and is ready for use. It keeps well, and is not apt to ferment.

8—**Glue** is the best all round cement known, but it must be good. It is the gelatine that sticks, not the dirt contained in common glue. A really good glue is cheaper in the end than a common one at half the price per pound, as the better one will take up a great deal more water. Fine glue is in thin cakes and is very brittle. When breaking it up, it should be lapped in some canvas as it is apt to fly—and the sharp edges cut like knives. If a basin large enough is used, the glue need not be broken up. Soak the glue in cold water 12 hours, then pour off all water not absorbed by the glue. The thickened water is useless, as glue does not dissolve in cold water. The water absorbed by the glue is just the quantity required to make the glue right for most purposes. Melt in a double glue pot, a plain pan will spoil it by overheating. Do not re-heat glue too frequently as it spoils, far better to make only a small quantity at the time. Good glue is stronger than the wood it joins. Leave the glue brush in the glue after using.

9—**Bottled Glue** is a very convenient method of using glue, but it is not stronger than the same glue used in the ordinary way. In a wide mouthed bottle half filled with Acetic Acid, drop bits of best glue (dry) adding more as they dissolve, till it is a thick mass. To use:—place a small bottle of this in a cup of boiling water, which will soften it, apply as usual.

10—**Gelatine Cement** is a finer quality of the above bottled glue, made with gelatine. It is equal to the much advertised cements for wood, glass, &c., and will stick almost anything. If required to be quite transparent, use isinglass instead of gelatine.

11—**Liquid Glue** is another form of bottled glue, but is always ready for use. It is, however, somewhat troublesome to prepare, so should be bought ready made.

12—**Copal Varnish, &c.** These are gums, &c., in solution, and must be bought ready made. Copal Varnish (thick) is the strongest. Paper Varnish is more flexible; both adhere well to glass, and can be used for fixing the paper transparencies sold for window decoration. Thin Copal Varnish renders thin paper translucent. The above require no preparation when used as cements.

13—**Canada Balsam** is specially suitable for joining glass, but is expensive. The best quality is quite transparent as a film between lenses, &c. The glass must be thoroughly warmed before applying.

14—**Plaster of Paris,** if for use as a cement, must be finest quality, as used by dentists and artists, and should be kept in a stoppered bottle. It will then be kept in good condition for several months. Ordinary plaster used by builders will not do for fine work. To mix:—use a glass tumbler, half fill with water, then sprinkle the plaster into the water so that each fragment is wetted as it sinks.

Continue this till the plaster just comes to the surface of the water. Stir well and it will gradually thicken until it sets. The state in which it is to be used depends on the work to be done. Do not add anything to the Plaster of Paris.

15—**Keens Cement** is a form of Plaster of Paris combined with Alum and re-calcined. It gives a harder surface than plain Plaster and polishes like marble, but is no stronger as a cement. Neither of the above will stand weather.

16—**Portland Cement** can be used merely mixed with water to the desired substance, it hardens like stone and sets quickly—has a smooth slippery surface if smoothed down while setting. May be mixed with two or three times its own bulk of sand, it is then strong enough for most purposes, and sets slower than cement only.

17—**Rubber Solution or Cement.** This is Masticated Rubber dissolved in Benzoline or Carbon Bi-Sulphide. It should be as thick as treacle to be thoroughly good. Should be bought ready made as it cannot well be made on a small scale.

18—**Celluloid Cement.** For joining articles made of celluloid a solution in Acetone should be used, and can be bought ready for use.

19—**Jewellers' Cement** is a preparation of Isinglass, Mastic Varnish, &c., somewhat troublesome to make, used for very small jobs, as cementing imitation jewels in rings, &c Marvellous holding power, but expensive.

20—**Shellac Varnish** is made by dissolving good quality shellac in Methylated Spirits or Wood Naphtha. It is used cold and is a very convenient cement for a vast number of purposes. The bottle must be kept well corked, and thinned if necessary with spirits.

21—**Stick Shellac** is good Orange shellac melted, and rolled into sticks for convenience of handling. To use :—the lac is melted and applied to the broken parts. Bleached or white shellac can be used for this and the previous cement, but is much weaker than the orange colored. Very dark color lac should not be used.

22—**Sealing Wax Cement** is a variety of the above, using sealing wax of a good quality instead of lac, but low quality sealing wax is too much adulterated to be of any use.

23—**Paint as Cement.** Good paint sticks to almost any substance that is not greasy or wet, so white lead or white lead paint will be found useful and cheap.

24—**Boiled Rice** is much used in Japan as a cement. It is of course a form of starch.

25—**White of Egg** is one of the best cements, and always handy. If only a small quantity is required, pierce the shell in two places with a needle, and blow into one of them.

26—**Knife Handle Cement.** Melted resin mixed with fine bath brick powder is used for this and similar hollow articles. Melted Alum is also a good cement for hollow metal handles.

27—**Glass to Metal Cement.** Plaster of Paris made up to a cream with saturated solution of Alum will do, if the parts are clean.

MENDING AND REPAIRING.

28—**Rivetting** is a very useful method of repairing thin metal, and not difficult. Holes must be drilled to fit the rivet, which is inserted and hammered down, at the same time holding down the parts to be joined. The rivets may be either soft iron, copper, or soft brass. They should be a good fit for the holes, and the parts joined should fit close together and be free from burrs at the edges of the holes. The length of rivet projecting should be equal to the diameter of the rivet. For very small work, ordinary pins answer very well, but before using they must be made red hot and quenched in cold water, this softens them. Place the pin through the work to be joined then, holding the parts closely together, cut off the excess of length with pliers having a cutting edge at the side ; a few light strokes will now upset the rivet.

29—**Soldering and Brazing.** Soft soldering is done with a solder containing lead melting at a low temperature. The parts are cleaned and moistened with soldering fluid. A fragment of solder is laid on the place to be joined, and a blow-pipe flame directed on to it, which melts the solder and makes the joint. In hard or silver soldering Borax is used for flux, and silver solder in place of soft solder. In brazing, grain spelter or fine brass wire is used. This is fully dealt with in Section "How to Solder."

30—**Fastening Knife Blades in Handles.** The easiest way to do this is to fill the hole in the handle with a mixture of resin and brickdust or sand, heat the tang of the blade and press it down into the mixture. For hollow metal handles, a stronger cement is melted Alum, or Keen's Cement may be used.

31—**Glue and its Uses** (see also par. 8). Glue binds porous materials as wood, &c., by entering the pores and so forming a vast number of grips. It should never be used on a smooth or polished surface, and should be well rubbed into the material. The work must be warm and free from grease or dirt. After gluing, the work must be tied or clamped together to keep the parts well in contact until the glue is set. For small work very serviceable clamps are made by cutting up an upholstery spring into rings. Other jobs can be clamped by twisting cord twice round the work, then tightening the cord by a stick passed through between the cords and twisting them.

32—**Hot Gelatine Cement.** This is a convenient form of glue and used same way. Melt by placing the bottle in a cup of boiling water and use hot.

33—**Liquid Glue** or cold gelatine cement has the advantage of being always ready for use, but it is not better than good plain glue and is more expensive.

34—**Gum and Resin Solutions.** For wood, bone, &c., Shellac Varnish (par. 20). For articles where a certain amount of flexibility is required, Copal Varnish (par. 12) can be used, but it takes longer to set.

35—**Glass and China** are best joined with Gelatine Cement (par. 10) which must be used hot, and the broken parts clean and hot.

After applying, the broken article must be tied up, or in some way put under pressure. This is the most important part of the repairing.

36—**Paint as Cement for China.** Where the broken article can be put away for a time to set, best white lead paint is a very good adhesive, or good white lead.

37—**Mending Cracked Bottle.** Silicate of Soda (or water glass) is very useful for this job, though hot gelatine cement (par. 10) can be used for it. Provide a good cork that fits the bottle well, heat the bottle till thoroughly hot, then insert the cork. Apply some of the water glass or cement to the crack, which will be forced in by atmospheric pressure as the bottle cools, if the cork fits well.

38—**Cementing Leather.** Thin leather is best joined by thick flour paste. See the leather is free from grease, rub the paste well into both surfaces to be joined, and tie or put under pressure till set. Rubber solution is also very convenient. For thick leather use rubber solution, but it will not make a joint if there is any grease present. Rub well into both surfaces and lay aside till quite dry, then lay the two surfaces together and hammer or press them to get a good contact all over. The edges should be bevelled off, so that the joined part is no thicker than the other parts of the leather. If subjected to any great strain the joint should also be either rivetted or sewn. The Gelatine Cement or Liquid Glue are both good for the thicker leather joint, as is also Gutta Percha Solution, and Marine Glue, also Cycle Tyre Cement.

39—**Rivetting Leather.** Thick leather should be rivetted instead of, or in addition to, cementing or sewing. When the rivet has large head, a washer on the other side must be used : if small head, a washer each side. They should be of copper and a good fit for the hole, and the parts to be joined must be held firmly down, or the rivets will bend instead of closing. Lay the work on any iron block and hammer down. Wire staples are a form of rivet, and a very convenient one. They are made from brass or other wire. Take say a pin, cut off head and point, now turn up each end at right angles to the length, and the staple is ready for use. Make two holes in the leather that will just allow the turned up ends to pass through, and turn over the projecting ends on the other side of the leather and hammer them down.

40—**Paper** when pasted expands and contracts again when drying, so that if pasted on a thin card, it pulls the card out of shape. To remedy this, paste a similar sheet or two small strips at the back of the board—both drying together will keep the board flat. Another way of preventing this is to gum the back of the paper and allow to dry : then moisten the gum, not allowing the moisture to penetrate to the paper, and apply at once. For very delicate work, as where a page of a book is torn across, apply paste with a fine brush or pointed bit of stick to the torn edges only. It will be usually found that there is a half thickness of paper to each edge of a tear.

41—**Picture Repairing.** In mending holes in Oleographs and other pictures mounted on canvas, it is best to cement a piece of

canvas to the back larger than the hole, leaving the part immediately surrounding the hole untouched. When this has set, draw forward the paper of the picture so as to expose the torn canvas. Lay the picture on its back on a table, and tease out the edges of the broken back, smooth down and allow to set. Any roughness must now be filled up with glue and whiting. When dry, damp the torn part of the under side of the picture and the mended canvas, and get the paper parts into position.

42—**Repairing Gilding.** The only difficulty in using gold leaf is the ease with which a slight breath blows it away. Transfer gold leaf has not this disadvantage. It is lightly stuck to thin paper, which it readily leaves if pressed on any surface that is more adhesive. For flat work use gold size, allow to become partly dry and sticky, press the transfer gold leaf on the sticky place and the gold will adhere to it. This method will stand weather. For inside work white of egg may be used when the gold size is not to be had. For irregular surfaces the loose gold leaf must be used. A thin sort of brush, called a gilder's tip, is used for lifting the bits of leaf. For sunk gilding as on marble clocks, &c., paint the part with gold size, and wipe off any that may be on the flat part. Apply bits of leaf with a small brush until all parts are covered, then press it down with a bit of wadding. When quite dry, the leaf that has not stuck can be dusted off.

33—**Bronzing.** When it is not desirable to go to the expense of re-gilding, a good effect can be got by dusting gold colored bronze powder over a surface of gold size or copal varnish. To prevent it tarnishing, a coat of parchment size should be given after the bronze is thoroughly dry. The size is made by boiling parchment cuttings in water for half-hour. It should be a thin jelly when cold.

44—**Re-Silvering Clock Dials.** These or other flat surfaces that are not subjected to handling can be done very easily as follows :— Clean the dial thoroughly with lemon or otherwise, then rub with the following composition, using a large cork for the purpose:—1 dram Silver Nitrate, 1 dram Salt, ¾-oz. Cream of Tartar, and enough water to make a paste.

45—**Replacing Missing Parts (wood).** Fine boxwood sawdust tinted to match the work is worked up to a paste with good hot glue. The broken surfaces must also be warmed and have a coat of glue. Apply the paste and work it to the required shape, it dries quite hard. Another method is to work up some soft bread between the palms till like putty, add some copal varnish and work up again ; this dries quite hard.

46—**Filling Cracks in Wood.** Wax and Ochre or Whiting, and any coloring required, are heated to melt the wax and well blended together, then used as stopping. In work where heat cannot be applied, a good stopping can be made from saw-dust and white of egg.

47—**Replacing with Papier Mache.** Missing or broken parts of many materials may be replaced by papier mache. Some soft

brown or newspaper is torn small and boiled to a pulp, then strained and squeezed to free it from most of the water, mix with thin glue and apply to the broken part. Another and easier way is to build up the missing part by gluing thick moist brown paper in layers until the required thickness is obtained. Rough parts can be removed with a rasp or sharp knife. When brought to shape, size with thin glue, and when quite dry, paint or varnish.

48—**Picture Frame Composition.** This can be bought ready-made, and when warm it is easily moulded to shape, and glued into position. It must be brought to a very smooth surface by glass paper before it is sized or gilded, or a coat of giue and whiting may be given to it, which is easily smoothed.

49—**Replacing Marble.** For small parts, use white of egg and marble dust, this will work up almost white. Silicate of Soda and marble dust is stronger and will stand weather. For large pieces use Keen's cement, if for indoor use. For outdoor, the missing part may be made of Portland Cement, and finished by dusting marble dust on the surface.

50—**Mending Marble, &c.** For a simple fracture, give a coat of good white paint (containing lead) to each of the fractured surfaces, and place in position. This takes some time to set ; gold oil size is better. Open cracks in stone or marble may be filled with some of the same stone in fine powder mixed with water glass (silicate of soda) six parts to one of the stone ; this sets quite hard. Brown stone or brickwork exposed to the weather is best repaired with Portland cement, either alone or mixed with sand. For large pieces, one of cement to three of sand will set to a hard concrete, and broken bricks or stones may be used to give bulk to it, but the sand, stone, and bricks must be thoroughly clean. For facing off use one each sand and cement. This gives a smooth surface, but too smooth for walking on. Cement can be got up as smooth as polished marble by smoothing with a wet board until set. The cement takes time to harden in proportion to the amount of sand added to it.

51—**Mending Marble with Plaster of Paris.** Plaster of Paris is one of the best cements for broken marble, especially when the surfaces to be joined are not polished. Mix as directed (par. 14) and apply to the fractured parts, which must be clean. For most jobs this is enough, but if a stronger joint is required, put in dowels of brass or copper rod. Marble is easily drilled with tools used for iron, if used slowly. A joiner's brace and a square shank drill will soon get through. The hole should be larger at the bottom than at the top. The dowel must be rough or bent, so as to hold better to the cement. The hole should be three times the diameter of the dowel. If exposed to weather, fill with Portland cement.

52—**Mending Wall Plaster.** If the repaired part is to be papered the mending is best done with Plaster of Paris, if to be painted, Keen's cement will give a better surface ; it takes longer to set, but sets harder, and can be polished like marble. In either case, the wall and the plaster surrounding the patch must be well wetted, or the moisture will be sucked out of the mixed plaster and make it

rotten. If the whole thickness cannot be done at once, the part done must be roughened by scoring in all directions with a knife, and wetted before the second coat is put on, unless done the same day.

53—**Repairing Waterproof Garments, &c.** In these repairs it is all important that the parts to be joined are free from grease of any kind. They should therefore be washed with Benzoline or Mineral Naphtha. The solution or cement, which for this purpose should be as thick as treacle, must be well rubbed into both surfaces to be joined with the finger, then stood aside until they appear quite dry. The two surfaces are then brought together, and either rolled or lightly hammered to bring them into intimate contact : nothing more is required.

54—**Celluloid.** This is very inflammable. It can be shaped if steeped in hot water, which softens it. To join—use Celluloid dissolved in Acetone.

55—**Egg Skin.** Very delicate work can often be mended with the inner skin of a raw egg, using white of egg as cement. It makes a strong flexible joint. The shell should be soaked in water 48 hours to loosen the skin, the shell can then be broken away in small portions without injury to the skin, which is then to be soaked in alcohol several hours to harden it. When treated in this manner the skin is very strong.

56—**Fish Skin for Repairs.** Few know the great strength of fish skin. For repairing articles that are not likely to get wet, it is only necessary to lap some of the skin round while wet. It contracts in drying, and binds broken parts strongly together.

57—**Raw Hide.** For larger jobs, raw hide or untanned leather can be used. It only needs well scraping on the inner side, the hair may remain on the outer. It must be well soaked before use, and used wet. Strips of this are used for protecting the corners and ends of hampers used for parcel post.

58—**Pins as Small Nails.** These can be used for repairing delicate woodwork, &c. Cut off length of pin required, and make a holder for it by splitting the end of a match. Both the point and head ends can be used for the purpose.

59—**Screws in Hard Wood.** To prevent screws splitting hard or thin wood, file a flat on one side of a screw, and use it to form a thread in the hole ; then remove and replace with an ordinary screw of the same size.

60—**Shrinking with Paper.** Many small articles that have split and which cannot be put under pressure in the ordinary way, may be drawn together by lapping wet brown paper round them. The paper contracts very much in drying, and exerts more pressure than would be expected.

61—**Pressure by Wet String.** Hemp cord contracts strongly when wet, so that if lapped tightly round a split stick, &c., and wetted, it will by contraction bring the parts together to make a joint, without marking the article as ordinary cramps would.

COPYRIGHT

Rubber Stamp Making

and

India Rubber Manufacture on a small scale.

By M. COLE.

* * * *

India Rubber in its pure or 'native' state has very little elasticity. It can be dissolved in mineral naphtha, or bi-sulphide of carbon. When the rubber is made into a paste with one of the above solvents and a suitable proportion of sulphur, it is known as *mixed sheet*, and if put in a mould and subjected to suitable heat, it undergoes a chemical change and becomes *cured or vulcanised rubber*, and is no longer affected by any moderate changes of temperature. Rubber intended to be soft and elastic is cured at from 280° F. to 300° F., but usually at 290° F. Rubber in any condition is spoiled by heating up to or near its melting point. Oil or grease of any kind spoils it. The proportion of sulphur, and the heat at which the mixture is cured, determine the varying properties of the resulting vulcanised rubber, from very soft and elastic to the hard vulcanite used for dental purposes. Rubber that has once been vulcanised cannot be worked up again, except to adulterate and give bulk to low class rubber goods, as toys or doormats. Pure rubber has the peculiar property that if freshly cut surfaces are brought into contact they unite as strongly as if the separation had never taken place. This is the principle on which rubber cement or solution depends.

Moulded Rubber Goods. Unlike cast metal articles, the rubber is not melted and poured into moulds, but a sufficiency of the mixed sheet is packed into the mould to fill it. The mould is so cramped together that the expansion of the rubber will not force it open. Heat is then applied, which cures or vulcanises it. The mixed sheet of rubber and sulphur which has been only mechanically mixed together is converted to vulcanised rubber, and is now elastic and returns to its shape after compression or expansion. When only single or a small number of articles are required from one mould, the mould may be of Plaster of Paris mixed with powdered Talc, or French Chalk, or some similar mixture. The process of making rubber stamps, given below, applies to all solid moulded rubber goods.

Rubber Stamp Making. The type is set up to the required style and lettering in a composing stick held in the left hand, while the letters are picked up singly with the right, and put into position on the stick. All the lines must be exactly the same length ; this is managed by adding spaces (bits of type metal) of varying thicknesses, either to the ends of the lines or between the words. Leads or thin strips of metal are placed between the lines of type so that they do not come too close together, to give a good appearance to the finished stamp. The composing stick is not as deep as the type, which projects about a quarter of an inch above it,

allowing the type when set to be tied with coarse thread into a compact block, which will bear handling without coming to pieces. To do this hold the end of the thread in the left hand, which also holds composing stick with type in it, then with the right hand lap the thread several times round the type and tie the ends. Then slide the block so made on a flat surface. As many blocks as the chase will hold are made up in this manner, and placed side by side, or their places may be occupied by blocks of wood or metal *furniture*. The *chase* (a metal frame) is then placed to surround the blocks of type. The sides of the chase are lined with strips of thin wood so that they do not injure the type. The whole is now wedged up tightly with wedges (*quoins*). If this is carefully done the whole lot may now be lifted or handled without fear of any of the type falling out ; but until the worker has had sufficient practice, it is best to do the work direct on the bed of the press, so that there is no need to lift the chase after locking it up. It will be noticed that the spaces used with the type are not as deep as the type itself. This is an advantage in ordinary printing, but a great drawback in moulding. To remedy this it is necessary to go over it and bring the low spaces up to the level of the shoulder of the type. This is done with ordinary soap of common quality, but it should be as soft as putty. The common cheap soaps are, when new, just suitable. Any small tool can be used for this part of the work. The whole surface of the type must be well oiled, but if too much oil be used the small details of the type will be filled up with oil, and will not make an impression on the compo. in moulding. Common paraffin oil does very well for this purpose. If the worker has no composing stick, the type can be set up in one corner of the chase, not forgetting that it must be set up to read backwards.

Making the Mould. The mould is made in the platen of the press, which has a narrow ledge near the edge, forming a shallow box. The compo. is mixed with water to the consistency of putty, and the box filled with it, smoothing the surface with a straight edge. The type being locked up in the chase, which is wedged tightly in the bed of the press, and the screws at the side being in position, place the top of the press with the composition downwards in position on the type, the side screws acting as guides to keep it in its right place : then lower it gently until the compo. rests on the type. Pressure must now be applied. The washers and nuts having been placed on the screws, screw down until the top of the press touches the safety blocks. This screwing down must be done by giving each of the nuts a half turn alternately to prevent one side being deeper than the other. The nuts must then be loosened, and the top removed by lifting carefully and evenly. If this has been properly done the compo. will have a clear impression of the type. If the impression is faulty, it is due to want of care in screwing down or lifting off.

Drying the Mould. The mould must now be thoroughly dried, using heat enough to drive off all the moisture. A warm oven does well for this, or the press top may be put on a small gas stove using moderate heat. Before drying the mould, it is necessary to make several holes in the compo. extending right through to the iron plate

at the back. These holes must be made in the spaces between the stamps. This will prevent the moisture forming hollows at the back of the mould. The drying must be continued so long as any moisture rises from the compo. The easiest way of testing this is to hold a bit of clear glass above the mould—if any moisture rises from it, the glass will show it at once.

When working with the smallest size outfit, which is intended for making only one stamp at the time, the following will be found the easiest way of making the mould. Having set up the type in the screw-chase, fill up the lower parts formed by the spaces with soap. A hole must now be cut in a card so shaped that the type will project through it. Oil the card and type well, and put a rim of oiled card so as to surround the type, but leaving a space of about half-inch between them. If the card and rim are well soaked in paraffin wax it will do as well. Mix the compo. and pour a very small quantity on the type, by blowing on this it will spread and form a thin coating all over the type. See that it is free from bubbles, then pour on a further quantity, enough to fill the ring. Allow it to set about a quarter-hour, or until hard. The mould may now be lifted off, removed from the card and dried.

Making the Stamp. Everything is now ready for making the actual stamp. A bit of clean writing paper is laid on the bed of the press to prevent adherence of the rubber (the chase and type having been removed). This is a better method than dusting it over with French chalk powder, a little of which must be dusted over the face of the mould, and all excess removed or it will clog the fine lines. Cut a bit of mixed sheet to the size of the stamp required, and lay it on the mould where the impression of the type comes. Bits of rubber may be used, as it is not necessary for any to be laid where there is no impression of the type, and the actual stamp never covers the whole of the surface. The surface of the mixed sheet should be rubbed over with fine powdered French chalk. Screw up the press a little and apply moderate heat. How this is done depends on the arrangements made. In the large press the gas stove is attached to it, but in the smaller sizes the press may be placed on any small gas or oil stove. The Thermometer is a fixture in the larger presses, but in the case of the smaller ones it is placed in position when ready for heating. It must be carefully watched to see that the heat does not rise higher than 295° F. or whatever temperature the rubber is intended to be cured at, and should be kept at that heat for say five minutes, to ensure the heat penetrating the whole of the rubber. In working with a small press, it is best to put the press in a small oven, which may be an ordinary fish kettle or other pan, with a well-fitting lid having a hole in it through which the thermometer is inserted, its bulb resting in a small jar of glycerine. This oven method is the safest way of curing, as the heat is then easily regulated. The press should rest on a sheet of asbestos board placed at the bottom of the oven. When no thermometer is used, a fragment of the rubber may be suspended by a thread through a hole, and withdrawn at intervals to see how the heat is progressing. When the rubber is cured it offers great resistance to a needle pushed into it, while the uncured sheet allows it

to penetrate easily. This is the best test to use when working with the smallest sized presses, testing with a needle the edge of the rubber seen between the mould and the plate of the press. It is as well to warm the mixed sheet before putting it into the press, as it is then easier to handle, and can be warmed by holding between the palms for a few seconds. The screws must be tightened a little after the press and contents are heated to about 220° F. or boiling water temperature, but too much pressure must not be used or the mould may crack. The rubber will itself expand a good deal in curing, and this forces it into the lines of the mould. When an extra thick stamp is required, two thicknesses of rubber may be used. If the surfaces in contact are clean they will unite. In making other rubber articles where a greater thickness than a stamp is required, the mould may be filled with layers of mixed sheet, provided the surfaces are clean they will form a solid article. When cool, the press may be opened, and the now cured stamp or sheet of stamps is ready for cutting up or trimming, and the stamp mounted as required.

Mounts and Mounting. A Rubber Stamp intended for real use must be mounted on a brass mount and fixed to a black wooden handle. The fancy mounts are useless for practical purposes. The brass mounts are usually sent out in the rough. After being filed up, the mount must be fixed to the handle by its spike, being careful to avoid bending the mount in doing so. Lay the rubber face downwards on a smooth level surface. Apply some of the cement hot to the face of the mount and spread it evenly, if necessary heating it again: then press it down on the rubber, which will adhere strongly to it if clean. Marine glue, or cycle tyre cement is best for this purpose. A small vice and a couple of brass finisher's files will be required to trim up the mounts, unless they are bought ready finished. The handles are in three sizes, of ebonised wood, and are easily driven on the spike of the mount.

Inks for Rubber Stamps. Best Quality Ink. This is Aniline Crystals of any required color, dissolved in glycerine. The quantity required to color the glycerine varies with the color. Violet goes furthest, but it should be as much as the glycerine will dissolve, and the Aniline color must be of the very best quality. (Some colors require to be dissolved in Acetic Acid, but these are few in number, others requiring alcohol). If any remains undissolved after using the solution, more glycerine may be added. Usually 1 oz. of Violet Aniline is enough for 1½ pints Glycerine. A little Methylated Spirits added to this will cause it to dry quickly.

Ink Pads. To make these, cut up some wood quarter-inch thick to size required, cover with a layer of tinfoil, such as is used for packing chocolate, &c., to prevent the ink soaking into the wood; on this a thickness of woollen cloth or two of flannel, to cover this use a fine cotton cloth—coarse will not do as it would ink the stamp unevenly. This cover is cut larger all round than the pad, and fastened to the bottom with either glue or paste.

Cleaning Stamps. Rubber Stamps require to be washed occasionally. This is done by allowing water to flow over the face at same time using a brush, then dry with a soft cloth.

COPYRIGHT

Window Ticket Writing.

By M. COLE.

* *

Window Tickets are written on cards of a special quality, with black or colored inks, outlined with a pen and filled in with brushes.

The Cards. Bristol board is the proper material for this purpose. Low quality white faced board will not do, not only on account of its appearance, but also because the paper on the surface is like printing paper, unsized, and the ink used would sink into it. If the proper boards cannot be obtained, a good thin paper of the quality of writing paper may be pasted on any suitable board. This is done with a paste made by mixing flour with cold water into a thin batter, free from lumps, then heat it over a gas stove or fire until it changes color, but not longer. It should, during the cooking, be stirred with a flat stick to prevent any sticking to the bottom of the pan. Spread on the paper evenly and quickly with a large brush, then lifting it by the corners lay it on the board so that the middle touches first, and gradually let the ends down. If this is carefully done there will be no air bubbles. Smooth down and lay aside to dry.

The Ink. A special ink is sold for the purpose, but the ordinary black ink of good quality well thickened with gum is often used. It must be the old sort of ink made with galls and iron, not the Aniline ink of which a great deal is now used. It is best to make the ink as required, whether for black or colors. Take the clear pieces of best quality *Gum Arabic*, put in a basin and water to cover it, put in a warm place to dissolve, and cover to keep the dust out. Add more water as required so that it is as thin as milk, then strain carefully through fine muslin, and bottle. To mix the ink, put a small quantity of dry color in powder on a plate, add some of the gum and blend it with a thin flexible table knife till well mixed, it is then ready for use. The dry colors can be bought at any paint shop. Ivory black or vegetable black are used for black ink. Aniline colors look nice but do not cover well and soon fade.

Pens for the outlines must be soft, broad pointed, not fine pointed, as they would not make a broad line without scratching the surface of the paper. Quills do well as they make a broad line with very little pressure.

Brushes. Several of these must be provided, from the small *crows* for fine work to larger size for filling in. Also some of the long haired *lining brushes* for the part touching the outline. These are similar to those used for lining on carriages.

Pencils used for outlines must be rather soft, good quality lead pencils, so that those lines not covered by the ink may be easily rubbed out without roughening the paper. The rubber also must be soft and of good quality. Good work depends greatly on proper attention to these small matters.

Designs of Letters. A good deal of artistic taste is needed to select the style of letters and figures that will make an effective card when finished. This cannot be taught. The letters are best copied from printed placards, and a good supply of specimens are easily obtained from old posters. The letters A, B, C, M, S, T, Y, W, are enough, as all the others are combinations of these, but there should be a full set of figures.

Waterproof Cards. Tickets written on card are intended only for in-door use. If for out-door use or exposed to rain, it is best to use oil colors on sheet metal, as it is not any more difficult than water colors on paper. An easy method of waterproofing the cards is to warm them, then give a coat of melted paraffin wax applied with a brush, or put in a shallow tin with the wax and apply gentle heat until it is evenly covered, then lift out and drain. Another way less dangerous is to coat the finished ticket with size made from good quality gelatine, and then give a coat of *Paper Varnish*, which can be bought at any oil shop.

Writing the Cards. The design must first be drawn with a soft lead pencil, then outlined in required color with a soft pen, making a broad stroke so as to form a hollow letter. The pen and brush work *must* be done in long strokes, and it is useless to commence to do the cards until this is mastered. Short strokes of either brush or pen will spoil the work. The letter O should be outlined with two strokes of the pen, but the card can be moved as well as the pen. In using the brush it is necessary to have as much command over it as the pen. The side of the brush must touch the line drawn with the pen all the time the brush is drawn along, while making the brush outline. Filling in is easy enough after that. If the pen is held between the first and second fingers, with the tip of the thumb pressing against the tips of those fingers, it will be found easier to draw long sweeping lines and curves, than when held the usual way.

Transferring Designs. The following is an easy method of transferring a design to a card. Lay a piece of parchment paper (used by grocers for packing butter) on the design to be copied, trace over the outline with a rather soft lead pencil, then place the traced paper with the marked side downwards on the card and rub well all over the surface with the bowl of a teaspoon, using a good deal of pressure. Enough of the pencil marks will be transferred to the card to be a guide for the pen when making the outline. The transferred design will be the reverse of the one copied. If there is any objection to this, draw the design a second time on the other side of the parchment paper. This is easily done as the design can be seen through the paper, especially if laid on a white surface. Another way is to blacken the reverse side of the design with the side of a very soft pencil, making a mark about double the width of the line traced. Apply this to the card and go over the design with a hard pencil. Enough of the blacklead will be transferred to be easily seen.

Stencils. When a number of cards are required having the same design on them, a stencil should be made from strong paper and the design perforated with a spiked roller. If this is laid on the card and a little blacklead or other colored powder dusted on it from a muslin bag, enough will go through to show an outline, which is easily followed by the pen.

COPYRIGHT

Stencil Cutting.

By M. COLE.

* *

Stencils, whether for marking packing cases or for ornamental designs, are cut either from sheet metal or from a special paper or other flexible material.

Designs for Stencils. A great deal of skill is required to make designs suitable for stencils, and no Western nation seems able to produce such beautiful effects as the Japanese. Many of their productions that were supposed to be printed from blocks are only stencilled on, and the difference can only be detected by an expert. This result is obtained by the skilful use of the *bridges* (the strips between the openings) as part of the design, and not as a fault or missing part as it often appears in ordinary stencil work.

The Bridges must be large enough and numerous enough to hold the parts together while in use, although the material is so much weakened by the parts cut away, the skill of the designer is shown by their not spoiling the completeness of the finished design. Where an original design is not necessary, very good ones can be copied or adapted from wall papers or printed cotton cloths.

Paper Stencils are made either from special oily paper sold ready for use, or from *cartridge* paper of good quality. If either of these are used with oil colors they require no preparation, but for water the cartridge paper should have two or three coats of shellac varnish before cutting. The design can be drawn before varnishing, as it can be seen through the varnish. Leather is sometimes used, but it is too expensive for ordinary purposes.

Cutting the Stencil. For this a knife is required having a short pointed blade, kept very sharp by frequent applications to an oilstone. A Picture Framer's Mount Cutting Knife does very well for this purpose. A peice of plate glass or heavy sheet glass should be used for cutting on. With a little practice it will be found easy to cut through the paper without spoiling the edge of the knife on the glass, but to begin with place a piece of thick pasteboard on the glass under the work. A metal straight edge should be used for straight lines, and some punches for round holes which are very difficult to cut with the knife.

Metal Stencils are usually made from thin sheet zinc or lateen, a special kind of sheet brass very thin and springy. Either of these can be cut with a sharp pointed knife, though not so easily as paper. Gravers with which they are usually cut are difficult to use. The easiest way to make the metal stencils is by etching with acid. Cover the metal with a thin coat of paraffin wax obtained by scraping a candle, warm the metal and sprinkle the scrapings all over it. If it is not hot enough to melt the wax, hold over a gas flame until it melts and spreads, being careful that the wax does not take fire. See that all parts are evenly coated, and pour off all the rest of the wax. In this case also the design may have been drawn

before coating the plate, as it can be seen through the thin layer of wax. With a sharp pointed tool go over the design so as to remove the wax and slightly scratch the metal, then apply the acid which will quickly eat through the thin metal. Equal parts of Nitric Acid and water are used for the brass, being careful to pour the acid into the water, *not* the water into the acid. For Zinc use Hydrochloric Acid (Spirits of Salt) which is cheaper than the Nitric. A wax taper with the end opened out like a brush does well for spreading the acid. The edges should be trimmed with a fine file. Thicker metal is often cut with shears (tinman's snips), ordinary shape for straight lines, and curved blades for the curves, but these can only be used when the design is large. For very thick metal chisels are used, with a block of lead under the zinc, the edges being dressed with a file.

Brushes for Stencilling. In stencilled designs the color is not painted on with the side stroke of the brush, but dabbed on with the end of the brush. Special brushes are made for the purpose, but an ordinary paint brush cut down to about one inch of bristles will do very well. The color is usually spread on a piece of board with an ordinary brush, and a little of this is taken up with a short brush and dabbed on the stencil.

Colors for Stencil Work are either ordinary oil paint or distemper as required to go well with the ground color. It should not be too thin or there is a tendency to work under the stencil. When working on wood, needles can be used to pin the stencil to the work to hold it in position, as the small holes they make are not noticeable, but on plaster they should not be used as they leave a much larger hole than on wood.

Straight Lines should be avoided in ornamental straight work as they seldom come out well, and are best done with a brush, but the difference is easily seen between the brush work and the dabbed on part of the design.

Another form of Stencil used to re-produce writings or drawings is made by placing a very fine file known as *dead smooth* under the paper and writing with a hard steel point. The teeth of the file will cause the line made to be a series of dots. To print from this, place a sheet of blotting paper saturated with aniline ink under the stencil, and a sheet of white paper on the top, then smooth down with a rubber roller as used in photography for mounting prints.

Gold Leaf. When this is used with stencil work the design is dabbed with gold size, and when half dry, but still sticky, the gold leaf is applied It should be in the form of *Transfer*—the gold is stuck to paper so that it is easily handled. The gold is laid on the painted design and the back of the paper lightly rubbed. The gold readily leaves the paper and adheres to the sized wood.

Perforated Stencils are often used for the outline of painted designs, and for gold lettering on glass. In these the design is drawn in outline on paper, and perforated with a small spiked roller (made for the purpose). This is placed on the work and some flour (contained in a muslin bag) is dabbed on it. Enough of this goes through the holes to mark the glass or board, and form a guide for the brush when the design is painted on.

COPYRIGHT

Bookbinding without special tools.

By M. COLE.

* * * *

The following method of bookbinding differs from that in general use in the trade, but is specially designed to produce strong, useful books, with the smallest number of tools and at little outlay, and it is easily learned. The following tools and materials will be required :

Needles. Darning needles will be found easiest to use by those not accustomed to such small tools. **Thread.** Flax thread as used by shoemakers is best for the purpose. It is sold in balls at about 3d. each.

Saw. A fine saw is required, either a small tenon saw or a fret saw if no other can be had.

Glue. Some good quality glue—common glue is no use for bookbinding and is not really cheaper in the end—it should be soaked in water for at least twelve hours. It will take up a lot of water and swell very much, so very little need be added when it is melted. Do not mix too much at a time, as repeated melting spoils glue.

Glue Pot. This should be of the proper double shape. If glue is melted in an ordinary pan it will be spoiled. If you have no glue-pot, use a tin canister slung with wire in a small saucepan so that the can does not touch the bottom of the pan ; but glue-pots are very cheap and are very useful for many other purposes.

Glue Brush. This should be a painter's sash tool, not too small as it is necessary to go over the work quickly. The brush after using should be well washed out, and dried by striking it just above the bristles against some hard object, this will cause the moisture to be sprayed out of it. It should never be left in the glue.

Paste. To make a good paste, put say : two tablespoonfuls of flour in a basin, add cold water to it slowly, a small quantity at the time, beating well with a fork or bit of stick so as to form a thin batter quite free from lumps, it should be of the consistency of thick cream. Pour into a clean saucepan and put on the fire or gas-stove. Keep well stirred to prevent it sticking to the bottom of the pan, until it changes color, then at once remove. It is better to make it rather thicker than is required, as water can be added ; if too thin and watery it is no use for the purpose. It is not necessary to add alum or glue, good paste sticks well enough for any work. If a very small quantity of borax is added to it while making, it will prevent the paste going sour, and care must be used not to use a brush with any trace of mould upon it. The paste will then keep good a long time. A small quantity of Carbolic Acid (Crystal) is better than borax, but is poisonous. Well made Starch as used for laundry purposes also answers very well.

Paste Brush. Thish should be similar to the glue brush.

Tape. Some strong tape is required, $\frac{1}{2}$ in. wide for small books and some 1 in. wide for larger ones, say those over the size of a magazine. A strip of strong calico can be used instead, but is not as good as tape.

Knife. A strong knife must be provided (as used by shoemakers) for cutting the boards, &c., (only the tip of the knife is used), also a stone for sharpening it on.

Press. If a screw-press can be had it will be very useful, but if not, a board a little larger than the book and some heavy weights (bricks or large books) will answer the purpose very well.

Boards. Millboards to form the covers. These should be at least as thick as a penny for books up to twelve inches, may be thinner for smaller ones and must be thicker for larger sizes. Old boxes may be bought from drapers for a trifle, and two thicknesses glued together, but they should be cut to near the size required before gluing and a weight put on them as soon as they are glued together. The glue for this purpose must not be too thin.

Square. Either a joiner's square or a drawing T square is required to get the top and one side of the boards square to each other, the other two sides may be disregarded as they will be squared in the cutting (this applies only to books bound "flush").

Paper. Some strong but thin brown paper must be provided for end papers, or the outer one that is stuck to the inside of the cover can be brown and the inner one white. This brown paper does also as a cover for the sides and looks very well. It can always be covered with any other sort of paper or cloth.

Cloth and Leather. Bookbinders' Cloth can be had in all colors for the backs of books having paper sides or for all cloth. Leather is also to be had in various colors and thicknesses, also an imitation leather that looks equal to the finest morocco. These had better be left until the cheaper sorts of material can be used with full effect. Leather must be stuck with paste, not glue.

It will be seen that out of pocket expenses are confined to very small amounts. Most of the tools, &c. required are to be found in almost every house. A sewing frame is useful, but it takes up a good deal of room, and most amateurs have to clear away all tools &c., after finishing each job. The tape method is quite as good and easier, in fact it makes a much stronger job than the ordinary method in use by bookbinders for the usual run of books.

India Rubber Binding. This old method has come into use again mainly for magazines. The back, instead of being folded and sewn, is cut so as to form a number of separate sheets. These are lightly cramped in a press, and some *thick* rubber solution or a special cement is well rubbed on to this surface so that some of it penetrates slightly. A strip of cloth coated with cement, and a half inch wider than the back of the book, is now placed on the back and well smoothed down, the extra width being cemented to the sides. The press is then tightened. When dry a cover can be pasted on. This is a very easy and quick method of binding and allows the book to open quite flat, but it is not very durable.

Binding a Magazine. It is best to begin with the easiest sort of binding. Magazines are very cheap and plentiful now, but the wire staples make them very inconvenient to handle and the thin covers soon come off. If bound according to the following directions they will form a good book with stiff covers that opens quite

flat, and will keep in good condition for a long time. This method is much better than binding several numbers together, as they make too heavy a book to handle comfortably. The cost is only that of the glue and thread used.

First remove the paper cover (this can be pulled off without tearing it if carefully done), then with the saw make four cuts in the back, just deep enough to cut into the innermost fold of each section. One of the cuts is made about half-an-inch from each end of the book, the other two about the middle a little farther apart than the tape to be used, which for this purpose should be about ½ in. wide and three inches long, or a strip of strong calico will do instead. Having made the saw-cuts, raise the ends of the wire staples with the knife and pull off one section at a time, this is easily done, while it is difficult to pull the staples out of them all at once. The first section will be found to be advertisements. Select three sheets (12 pages) to form the cover, and if there are fewer than twelve pages of advertisements at the end, part of those at the beginning can be used to make up the required number.

To Sew. Thread the needle with about a yard of thread. Sit close to the edge of the table, left arm and elbow resting on it. Lay the three sheets that are to form the cover on the table, open the section and place the left hand inside the fold, now pass the needle in at the end saw-cut with the right hand, then catching the needle with the left hand pass it out again at the nearest of the two middle cuts, and in again with the right hand at the next cut, thus forming a small loop, then out again with the left hand at the end cut. The tape can now be passed under the loop of thread in the middle of the back, which will hold it in position during the remainder of the sewing. Now lay the next section of the book on the first one and continue sewing as before, starting at the end at which the needle and thread is, passing the needle in and out as before, when at the middle stitch it will of course go round the tape. You have now two sections sewn, but the ends of threads are loose and must be tied, the short end where you started sewing to the long one in the needle ; it must be tied tightly yet not allowed to cut the paper. Now put on the third section and sew just as you did the first one, when at the end hole the thread must be fastened. To do this, pass the needle between section one and two, just above the thread that unites them, then out at the end of the book, then through the loop so formed and draw the thread tight, being careful not to break it. The other sections must be sewn the same way until all are completed.

Gluing. Lay a piece of waste paper, a little larger than a page of the book, between the sheets forming the cover and the first page of reading matter, this is to protect the inner pages from being splashed with glue. Do the same at the other end. Now give the alternate pages that are to form the cover a coat of hot glue, well and quickly spread ; smooth each down as it is done, and at the outside give the end of the tape a little glue to hold it down, and put a bit of waste paper on it to prevent it sticking to other things. Do the same at the other end, and see that the tape is not loose at the back. As soon as the gluing is done, the book must be immediately put under pressure and a little glue well rubbed into the back, it can

then be left overnight to dry. When several are in hand, do not leave them loose until all are done, but put each one under pressure as soon as glued. After setting overnight, it will be found that the glued pages form a cover quite stiff enough for ordinary use, but if desired it can be made stiffer by inserting a thickness of card between the sheets at the time of gluing. The outer cover has now to be put on. This is best done with paste, as it causes the paper to expand a little, and as the paper shrinks again in drying, it becomes tight on the boards. If for a library, a piece of thin calico or muslin may be pasted on the back before the outer cover is put on. If this is done, the cloth and the part it is put on must both have a good coat of paste, and it should be allowed to dry before the paper cover is put on.

Binding a Book. When binding weekly numbers of a paper into a volume, do not use more than twenty-six, or it makes too heavy a book. Most journals, of say 16 pages, have the last two full of advertisements. If it is not intended to include these, they can be torn off and the first leaf pasted on to the second one by a quarter inch of the margin, this will make a thinner volume ; or the advertisement pages can be used for cuttings from other papers. End papers, the blank pages at beginning and end of the volume, must first be pasted on. To do this, take a sheet of white paper and one of brown for each end, a little larger than a page of the book, paste a quarter-inch of the edge of each one, then put the pasted edge to the fold of the first section, and turn over the edge so that the pasted part of the paper is on the inner side of the fold, then do the same with another sheet of brown, putting it over the white one. This is not usually done by bookbinders, but it adds greatly to the strength of the book. Do not forget that end papers are put at the *beginning* of the first section and at the *end* of the last one. It is best to do the pasting of a lot of books together, as they must be quite dry before they are sewn. When about to commence stitching a volume, lay the sections one by one on the table so that they are piled up quite evenly at the back and top end, then put a board on them and weights, or use a cramp to squeeze them together, then cut the nicks in the back with the saw, allowing for two tapes for all up to thirteen inches and three tapes if larger. For books twelve inches or upwards the tapes should be one inch wide. Proceed with the sewing in same manner as described for a magazine. After sewing, glue the ends of the tapes to the fly leaf they rest on, see that they are drawn tight and not in wrinkles under the stitches. Have some boards ready for the covers. These should be of strawboard as thick as a new half-crown for twelve-inch books, and must be cut straight at one side and end. Give a coat of glue to the brown paper on which the tapes rest and a little along the straight edge of the board. Place the board at once in position on the brown paper, even with top edge of the book and about one-eighth of an inch from the edge of the back. The other two sides of the boards need not be considered as they will be trimmed off in cutting the book. At once reverse the book, and do the same on the other side. A board must now be placed on it, a little larger than the book and even with the back and weights on it, then go over the back of the book with a

coat of glue, well rubbed in, so that it penetrates a little between the sections, allow to dry. If a number of books are in hand, each one can be added, as soon as glued, to the previous ones, removing the boards and weights for the purpose and replacing as soon as possible. In this case all the backs can be glued when the pile is complete. After drying say twenty-four hours, the backs can be strengthened by gluing a strip of calico on them extending to about two inches on the sides. If this is done, a blunt knife should be used to press the cloth down at the edge of the board.

If books are intended for use only, and appearance is of no consequence, they can now have a cover of colored cloth pasted on. This may be in one piece to cover back and sides, and should be a little larger than is required, both the cloth and book should receive a good coat of paste and be allowed to dry thoroughly. They can then be cut *Flush*, that is, the book and cover at one operation, which is far the easier way, and should be done with the first few books bound before trying anything more difficult. Instead of covering the whole book with one piece of cloth, a smaller piece may be used (or leather if preferred) extending about an inch and a half on the sides, and the remainder covered with brown paper, which has a good effect and can always be covered with some other material. A better effect is got by adding the covering after the book is cut. To do this, select a piece of cloth or leather three inches wider and an inch and a half longer than the back of the book, give this and the book back and two inches of the sides a coat of good paste. Lay the cloth on the back of the book, and smooth down the sides. Now lay the book open on the table and divide the brown paper by which it is stuck to the boards for a distance of about half-an-inch with a knife. Turn in the top end so that the part at the back laps over on itself, and those at the sides lap over on to the inside of the cover. The turned-in part at the back should have a little extra paste on it. Treat the other end the same way, then close the book and put under pressure to dry. The remainder of the cover can be covered with paper or cloth cut a little larger than the board and turned in. When treating a book this way, two sheets of brown paper must be used for end papers, unless the outer cover is of the same paper as the ends. When done in this manner the cloth or leather at the back adheres to the book and bends with it. This causes creases in a book that is much used, but it is the strongest way of binding. If it is desired to avoid this, a strip of thick paper, or thin card can be pasted on to the cloth or leather before it is applied to the book. In this case of course the other side of the strip is not pasted.

The above method produces a good strongly bound book, with very little trouble, but it has the drawback that the sides do not project beyond the leaves of the book. It is, however, much stronger than the books usually sold ready bound, which are only glued into ready-made covers.

Well bound books are pressed by hydraulic or other pressure, or on a smaller scale, by hammering with a heavy hammer to consolidate them. This makes the books very nice so long as they are not used, but any such books if read through, and each page opened

quite flat, are thereby put out of shape, as they never close up again as tightly as before.

Stapled or Nailed Books. The ease and quickness with which a book can be bound is the only recommendation of this method. The first and last section being prepared with end-papers as described, all the sections are piled up, taking care that the back is quite even. Now drive some tacks or thin wire nails a ¼ in. from the edge of the back, turn over the lot and drive in an equal number from the other side, and the book is ready for a cover. The number of nails depends on the size of the book, usually four to six are enough. For thin books tacks will do, for thicker ones thin wire nails. They need not go quite through the paper as the nailing is done from both sides, though if extra strength is desired, longer nails can be used to project ¼ in. through the book and then clinched down. See that the nails are not too near the top and bottom of the book or they will be in the way when cutting the edges. It is advisable to draw a line as a guide for the nails. Pasteboard sides are now to be glued on to the end papers, not too close to the back, in fact the edge had better be just over the row of nails so that a hinge is formed, and a strip of colored calico pasted on the back extending about one to two inches over the sides. The book is now ready for cutting, after which the sides are covered with thin colored paper pasted on and the margin turned in over the edges of the covers, so as to hide the cut edges of the boards.

Cutting the Edges. The best way to cut the edges of a book is to get someone else to do it.

Hand cutting is slow work, and all printers now have Cutting Machines. Any printer will cut half-a-dozen small books for sixpence. However it is just as well to know how to do the cutting :—

A Cramp should be made of two pieces of strong wood, oak is very suitable, say eighteen inches long and two inches square, also a pair of half-inch bolts and nuts about six inches long with washers and some packing for tightening up when small books are pressed. The book to be cut is cramped in this, the edges of the wood are to act as a guide for the knife, which must be short and broad bladed, ground to a point, as all cutting is done with the point, which penetrates the paper about one-twentieth of an inch, so that it is necessary to make twenty cuts on a book one inch thick—it being easier to make a number of light cuts than a few heavy ones. When using the knife, the blade must be pressed against the wood just as if the object was to polish the one on the other, giving a little downward pressure at the same time. When cutting in this manner, see that the book lies on the table with the edge to be cut *away* from you, lean over the work. If otherwise placed, with the edge to be cut towards you, there is great risk of the knife slipping and causing a dangerous wound. A whetstone should be close at hand and the knife applied frequently, as it must be very sharp to cut paper well.

Making a Cover. When it is desired to bind a book to have a better appearance than those that are cut flush, covers can be made and put on to them at any time after binding them the easy way. It is as well to pull to pieces the cover of an old book to see how it is built up. A great deal depends on getting the measurements correct.

Lay the cloth cut to required size face downwards on the table and give it a coat of glue. Two boards cut to size of finished book are glued and placed on it just far enough apart to form the back of the cover. Glue a strip of brown paper on this part leaving a space of $\frac{1}{8}$ in. between the paper and the edges of the boards. The edges of the cloth projecting over the boards are now turned over on to the boards and the whole left to dry. The cover having been made, it can be glued on to the book after being cut just as directed for putting on the boards, but such work is only held together by a bit of cloth forming the hinge. The book being cut, glue a strip of cloth not quite so long as the height of the book and wide enough to lap over say $1\frac{1}{2}$ in. on the sides. At once give a coat of glue to the inner sides of the cover and to the outer sides of the end papers, put the book in the covers and apply pressure till set. When leather is used for the cover it must be stuck on with thick paste, well rubbed into the grain of the leather. The edges of the leather must be bevelled off to a fine edge. This is done on a smooth hard surface, a piece of glass answers very well for it. Use a very sharp knife for the purpose. If this is not done the leather shows a ridge where the cloth covers it. It is also necessary at all edges of leather where they are pasted on to other parts.

Rounding the Backs. After the back is glued it is easily pushed into a round shape, when necessary a hammer can be used to it; it should then have another coat of glue, and a strip of brown paper glued to it. The rounding is important, not only for the appearance of the book, but when the back is rounded the end sections overhang the sides and form a space in which the board forming the back fits. If left flat the back is pulled out of place every time the book is opened.

There are several sorts of leather used for books, calf and morocco being the best. For ordinary use skiver is most suitable and cheapest. It can be strengthened by a layer of thin cotton pasted on the wrong side. For greater strength sheep or goat skin can be had in various colors, and it can be improved when it shows signs of wear by a suitable polish.

When leather or cloth is glued direct to the back, a layer of paper should be first glued to the book to prevent the hollows between the sections showing through the leather.

Sprinkled Edges. These are done with colored ink or the dyes sold for household use. Dip a brush in the color and strike it against a stick, which will cause the color to be sprayed out on to the work. The covers must be protected with paper.

Lettering the Backs. Gilding is the proper way to do this, but there is the expense of metal letters to get the impression. A very good effect is got by using gold size and then gold leaf. Draw the design or number across the back in gold size, using a pen to do the outlines, and a very small brush to fill in the heavier parts, at the same time put a little of the size on a bit of waste leather for testing. When the lettering is partly dried, so that it is sticky or "tacky," apply a bit of gold leaf to it, a little larger than the design, then press down with a piece of cotton wool and allow to dry thoroughly, then dust off superfluous gold. If any sticks round the

edges it may be removed with a piece of rubber. Transfer gold leaf is best for this work as it is sold stuck to paper, it readily leaves the paper and adheres to any surface that is more sticky. The price is only one penny per leaf.

If a cheaper method is desired, gold colored bronze powder may be dusted on to the sticky letters, and what does not adhere dusted off. The so called "gold paint" will not do for this purpose, as it is impossible to get fine lines and even edges to the letters with it. Aluminium Powder can be used in place of bronze powder. It has the advantage of keeping its color for an unlimited time ; while the bronze powder is blackened by the fumes of gas, &c. Do not use the imitation gold leaf known as Dutch metal, as it is much too thick for the purpose and soon blackens. A very good method of marking books is to make a stencil of the design, and dab the gold size through the openings. This method is specially useful when a number of books have to be lettered.

Gold Lettering with Type. Bookbinders use brass letters for stamping the names, &c., on book backs, but very good effects can be got with ordinary type, as the heat required is not great and type is hard enough to be used a number of times before it loses its sharp edges. The Vehicle used in this case is called "Glaire" and is prepared by beating the white of an egg into a froth, then allowing it to stand for a time, till the fluid part settles to the bottom of the vessel. This is the part that is used for lettering, and it is not unfit for use when it becomes rancid.

To prepare the leather : clean the places to be lettered with a bit of rubber, then give a coat of glaire (a little larger than the lettering) and allow it to dry, but do the lettering before it becomes hard. Now with a rag having a slight trace of grease (olive oil or tallow) wipe the place and apply a little of the gold leaf to it by pressing it on a pad holding the cut up leaf. For this purpose loose leaf must be used and it is awkward to handle as it is apt to be blown away. The stamp or type is heated till very warm, but not hot enough to burn the hand (the safest way to do this is to heat it in boiling water), wipe dry and then grease slightly with the rag and press on the gold leaf, which will then adhere to the leather.

Some workers prefer to pick up a bit of gold leaf by touching it with the greased type, others pick it up with a brush called a tip, which is kept slightly greased by wiping it on the hair. Or the leaf may be cut together with the paper of the hook in which it is sold, with scissors, and each bit lifted into its place either with the brush or a knife. In all cases the difficulty is to handle the gold leaf. It is usually cut on a pad of leather, surrounded with parchment to prevent blowing away, and cut with a smooth-bladed knife pressed on it with a sliding movement. In lettering leather it is advisable to put a little paste on the place to be lettered and to rub it well in to the pores, wiping off all that does not penetrate, this gives a better surface to the gilding. The pasting must be dry before going farther with the work.

It will be found easiest to do the lettering on a separate bit of leather, then bevel the edges at the under side, and paste on the book back. If this is carefully done it makes a very neat job.

COPYRIGHT

Picture Framing.

By M. COLE.

* *

TOOLS AND APPLIANCES AND THEIR USE.

Saw. This should be a Backed Saw having thin blade and fine teeth. The finer they are the smoother the cut surface will be, a clean cut is impossible if the saw is dull or buckled. If a strip of thin wood is placed on the surface of the mould and cut with it there is less risk of a rough cut. It is important that the sides or ends are of exactly equal length or the frame will be crooked. The angle of the cut is 45° This is easiest measured by folding a square of paper diagonally, but when a mitre board is used it is only necessary to mark the length of the finished side.

Mitre Board. To ensure the cut being at exactly the right angle, a box or board having guide cuts is used. The box ensures more accurate work as the saw is kept quite vertical, otherwise the board is quite as good and much easier to make. For ordinary work take a board 15 in. long, 6 in. wide, and 1¼ in. thick, on this screw another board same length 3 in. wide and 2 in. thick, so that the lower board is covered half its width from one edge, then having very carefully marked an angle of 45°, make two saw-cuts in the upper board so that if continued the cuts would meet and form a V. A third cut is usually made across the upper block at right angles, half way between the other two, for cutting moulding straight across. The moulding is placed on the lower board and held or cramped firmly against the upper one, then the saw is placed in one of the diagonal saw-cuts which acts as a guide while the moulding is being cut. A mitre board of this sort is easily made and when the saw-cuts get worn so as not to guide the saw accurately, fresh ones can be cut. Before screwing down the narrow block to the wider one, the position of the saw-cuts must be marked so that the screws are not in the way of the cuts. If a couple of extra strips say 1½ in. square are screwed on the upper board as shown in the diagram (at end), the mitre block can be used as a shooting board.

Plane. To make a neat corner joint a thin shaving must be taken off the cut surface left by the saw, and a finely set plane is necessary for this. It will also correct any small error in cutting and ensure the opposite sides being exactly the same length. When using gilt moulding there is danger of the outer part splitting at the end of the stroke, unless the support on the shooting board is almost level with the end of the moulding. It is as well to trim off

the extreme end with a knife to avoid this. The plane should be a long one, preferably iron, so as to get a long bearing on the edge of the shooting board, but good work can be done with the old-fashioned wooden trying plane. The plane is used on its side, the face pressing against the edge of the raised part of the shooting board, the moulding resting against one of the ribs screwed on to it at the correct angle, and any error in the correct position of this rib will spoil the joint. The plane is used pushed along for those surfaces where the outer edge is furthest away, but pulled towards the worker when doing the other half of the joint. When a large quantity of work is done it is worth while to purchase the special machine to trim the ends instead of planing as it ensures accurate work and is very quick. For occasional work one of the ordinary small iron planes now so cheap will do, or even a file (8in. rough) may be used with success to trim up the surface, the file being flat on the table and the moulding rubbed on it one way only.

Glue. The joint must be glued in all cases. The glue must be melted in a double glue pot, or as a substitute in a can suspended in a larger pan of water so that it does not touch the bottom of the pan. The glue, which must be of good quality, should be soaked in cold water several hours, then pour off all the water the glue has not soaked up, and melt in the special glue-pot. It will then be right strength. Do not re-melt the glue too often, but better prepare a little at the time. After using leave the brush in the glue. The glue sold in tubes will do, but is too expensive for general use.

Vice. This is the same as used for metal work, and must be large enough to hold a piece of moulding while another piece is nailed to it, which is the usual method of Frame Making. When a joint is made up in the vice, one length is firmly gripped in it with the cut surface towards the worker, a sprig having been driven a little way into the other, the cut surfaces are glued and placed together, the sprig is then driven home by a couple of blows with the hammer. While doing this it will be found that the part held in the hand will have travelled about $\frac{1}{8}$ in. from the position it was at starting. This must be allowed for, so that what would otherwise have been a fault, will ensure a correct joint.

Cramp. In another and easier method of Frame Making, the nails are put in after the frame has been glued and the glue has set, the correctness of the corners being insured by the frame being cramped together as soon as glued, the glue drying while the frame is in the cramp. There are many forms of cramp for this purpose, some expensive, others easily made. One way is to screw four strips of wood (about 2 in. square) to a table or board so as to enclose a space a little larger than the frame. One side and one end rest against the strips, the other side and end being tightened up by wedges. Another way that does not require the permanent use of a table or board is with **"Spanish Corners."** To make these take four circular blocks of wood about 4 in. diameter and $1\frac{1}{2}$ in. thick. Cut away a quarter of the circle so as to fit the corner of a frame, then cut a deep groove in the opposite corner of the block to hold a

cord. To use these place one at each corner of the glued frame, then tie a strong cord twice round the whole (resting in the grooves of the corners). The string is then tightened up hy inserting a stick between the cords and twisting them, or better twist two opposite sides so as to get equal pressure, and leave until the glue is set.

Nailing Corners. After the glue is set remove the cramps and nail the corners of the frame, holding it in a vice or against some firm support. If the frame is a large one screws should be used. but they should be thin. A suitable hole having been bored for the screw, part of it should be enlarged so that the head of the screw can be below the surface of the frame, the hole is then plugged with wood or putty. Another method very suitable for small frames is to put a saw-cut at each corner as deep as it is safe to go, and glue into it a strip of hard wood. When set trim off all that projects.

Brads or Sprigs. A brad-awl of suitable size must be provided to start the holes for the brads. The old style brads with blunt ends are less liable to split the wood than the modern pointed wire nails, as the former punch out a bit of wood, while the latter push aside the fibres, starting a crack.

Picture Rings or Screw Eyes must be inserted with care, and must be of size suited to the weight of the picture. If too large they will split a thin moulding or go through to the front. For small pictures one at the top is enough, for larger ones use one at each side. The position or distance from the top depends on how the picture is to hang. If flat to the wall they are placed near the top, but if placed lower down the picture will be tilted to an angle. This should always be done when hung high up. By using a short cord the nail from which the picture is hung, and the cord, will be out of sight.

RE-GILDING FRAMES.

The only difficulty in re-gilding frames lies in lifting the gold leaf on to the frame, as it is so easily blown away. If this is once mastered the remainder is easy, and the leaf is very cheap considering the surface it covers. Where the surface is smooth and level, even if curved a little the transfer leaf can be used which is sold adhering slightly to the paper on which it is mounted, so that it is easily transferred to the parts to be covered. The ordinary gold leaf as sold is packed between the leaves of small books. To lift the leaf a special kind of thin flat brush is used (Gilder's Tip). This, when wiped on the hair of the head, has the power of causing the gold leaf to adhere to it, so that it can be lifted from the pad and so transferred to the surface to be gilded. The gold is lifted with the blade of a knife from the book in which it is sold on to a pad or cushion covered with leather and protected from drafts on three of its sides by a parchment screen, and it is cut with a smooth-edged knife which need not be very sharp. The whole edge of the blade is pressed on the gold, and a slight stroke will cut the leaf without injuring the pad. The surface to be gilded must be prepared by smoothing down all rough parts, stopping cracks with either putty or the special

compo., replacing missing bits of moulding, &c. The surface is then carefully painted with gold size. When this is partly dried but still sticky it is ready for the gold leaf. The leaf is now applied with the Tip in pieces of suitable size, the edges of which must over-lap, and dabbed down with a large soft camel hair brush to get the leaf into the details of the moulding. Smaller bits of leaf are placed to cover such parts as are not covered by the larger pieces. Parts of the moulding with much detail must have two layers of leaf. After drying a couple of days, the work should be given a coat of clear varnish.

Repairing Moulding. Gilded frames, especially the cheaper kinds, are apt to lose part of their moulding, which is loosened by the unequal expansion caused by the heat and dryness of most rooms. To replace these parts, a mould must be taken from an uninjured part of the frame. Take some of the crumb of a fresh loaf, knead it between the hands until it is like putty, then having oiled the surface to be copied press the paste on to it and carefully remove, it will have taken an impression that can be used as a mould. The easiest way of making the new bit is by casting it in plaster. Mix some Plaster of Paris of fine quality (as used by dentists and artists) with water to form a thick cream, pour into the mould previously oiled, and allow to set hard, which usually takes quarter-hour, then remove carefully, destroying the mould if necessary. To avoid air bubbles, pour only a small quantity of the mixed plaster into the mould, then blow through a tube until the surface is well covered, when the remainder can be poured in. The cast must be thoroughly dried by gentle heat, then trimmed down to the required size, and glued into place. Small cracks or holes are filled with a putty made from the glue size mixed with whiting of good quality free from lumps, and used while warm. The new parts and all stoppings must be painted over with thin shellac varnish until no more is absorbed, it should be colored with ochre or other yellow pigment.

Gold Paint. When the repair is not worth the expense of gold leaf, a good job can be made with so called *Gold Paint*, but to get the best effects it should not be applied as a paint, but dusted on as a powder. The material known as *Bronze Powder* is a Sulphide of Tin, and can be bought in a great variety of shades from Silver to deep Copper, but the silver should be avoided, and if that shade is required Aluminium Powder used instead. The light gold color is most useful as it allows for a little toning down by the lacquer. The frame is painted over with thin glue made from best gelatine, and when partly set but still sticky, the powder is dusted over the surface preferably from a pepper box, to ensure the whole of the surface being covered. All that does not adhere to the frame is dusted off with a large camel hair mop brush, and can be used for another job. When quite dry the surface must have a coat of clear lacquer. A better vehicle and one suited also for out-door work is Clear Copal Varnish, diluted with equal quantity of Turpentine.

Dutch Metal is a gold colored alloy having the appearance of gold leaf but much thicker, so that it is easy to handle and is very cheap. If lacquered well it will keep bright for years.

MOUNT CUTTING.

Many pictures such as water colors or photographs look best when framed with a broad border of some contrasting color, usually white or cream. Some are merely pasted on the mount, but the best effects are with cut-out mounts, the picture being seen through the opening, the sides of which are bevelled. The board must be cut at one stroke or the smooth clear edge will not be got. The special knife is easiest to use, but a good pocket knife with a small blade ground so that the edge ends in a point tapering off from the edge to the back will do, if the handle is large enough to be firmly grasped without cramping the hand. It must be very sharp and frequently applied to a fine oil stone. The board must be firmly held down on a table that will not be injured by the knife edge which cuts through the mount and slightly cuts the table at the one stroke. Some workers use a sheet of glass to cut upon, but this dulls the point of the knife. In the best work the edge of the cut is covered with a narrow strip of gilt paper specially made for the purpose. As not more than $\frac{1}{16}$ in. should show on the flat surface, this is not easy to do. The paper should be cut $\frac{1}{4}$ in. wide so as to be strong enough to handle, the remainder being at the back of the mount. Allowance must also be made for the paper shrinking in length when drying. The best way to do this is to cut the edge very exactly, then draw a pencil line on the plain side of the paper allowing just as much as is required to appear on the flat and on the bevel of the mount, the ends having been cut to the angle required to meet at the corner of the mount, the board is placed on the gilt edge (which is plain side upwards) so that the lower edge of the cut is exactly at the pencil line, the remainder is then turned up over the cut part where it is to appear, and smoothed down. The best quality is coated with real gold leaf, if this is too expensive the edge should be left plain rather than spoil it with imitation gold.

FRAMING THE PICTURE.

The frame being made and glass cut to fit and carefully cleaned, a narrow strip of brown paper should be pasted partly on the glass, the remainder on the frame at the inside so as not to be seen from the front, this is to prevent dust getting into the picture between the frame and the glass. The mounted picture is placed in contact with the glass, and the thin wood backing is placed in position and secured with brads or small nails, usually by pushing them in with pliers, but a stroke of the hammer should also be given. If the hammer head rests on the back while making the stroke there is no danger of breaking the glass. A sheet of strong brown paper is then damped and glued on the back of the frame. It will contract in drying and then be quite tight, any superfluous paper is removed with scissors.

Corners. A moulding having a heavy ornament does not join up well at the corners, to correct this special corner pieces are used. They are made from the same compo. as the frame moulding pressed while hot into moulds of brass or boxwood, while still soft they are shaped to fit the corner and glued down.

Mounting Pictures. When a cut mount is used, a portion of the lower surface not too near the edge is glued and carefully laid on the picture so as to fix it in correct position. In using a plain mount the edges of the picture are pasted and the picture carefully placed in position.

HOME-MADE MOULDING.

A Moulding of simple design is easy to make. If of Oak or other hard wood that will polish they are very effective, while those of soft wood when painted with Varnish Paints (Enamel) look equally well, and for some purposes are very suitable. The painting being done after the frame is made up the joints can be trimmed up a little, so that for first attempts this style is one of the best. Wood free from knots and of suitable section is taken, say 1 in. square (*see diagram*) a quarter of this is removed either by a rebate (rabbet) plane or with a saw. If the latter is used it is necessary to fit it with a guard to prevent it cutting too deep. This need only be a board at each side of the saw cramped to the blade and of such width that one side rests against the inner edge of the back while the other side comes to within $\frac{1}{2}$ in. of the edges of the teeth. The inner edge of the bead is next chamfered (bevelled) off with the plane as required say to reduce it to $\frac{1}{4}$ in. A bead must now be made on the outer edge of the mould. If there is no beading plane this can be done with a makeshift tool easy to construct. Screw an ordinary 1 in. wood screw into a bit of wood allowing the head to project $\frac{1}{4}$ in., then file away half the projecting part, and slightly round the lower edge. This, though not correct shape of cutting edge, will work a very good bead on wood of straight grain. The two exposed surfaces must of course be planed up before any work is put on them.

FREAK FRAMES.

Some of the so called *Artistic* frames are easy to make. One sort is covered with coarse canvas and gilded, others are made from wood direct from the saw and gilded on the rough surface. In these a frame of plain wood without moulding is used. A piece of canvas two or three inches larger all round than the outside of the frame is taken and the edges turned over and secured to the back with tacks, then part of the middle of the canvas is cut away, and a cut made at each of the corners to within $\frac{1}{4}$ in. of the frame. The flaps are drawn tight and tacked down. It must have a coat of glue size before it is painted or gilded. One of the ugliest forms of freak frames is made from pieces of cork. The corks of wine bottles are cut in circular slices $\frac{1}{4}$ in. thick, each of these is cut across and glued by the narrow flat surface to the frame of plain wood. The whole monstrosity is then varnished. If a still uglier frame is desired it can be made by gluing small paper stars to a wood frame instead of the bits of cork.

Lincrusta Frames. Very beautiful effects can be got by using *Lincrusta* or other wall covering having a raised design. Short lengths of this can be bought very cheaply from decorators. Suitable portions having been selected, they need only be glued to a plain frame. They can be gilded or tinted as desired.

GLASS CUTTING.

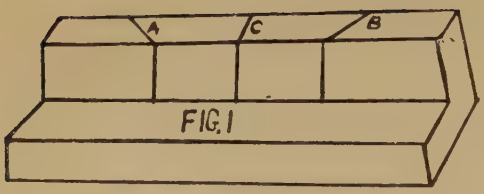
The roller glass cutters now so cheap do this well if of good quality. The glass is laid on a smooth table that has been covered by several thicknesses of newspaper or a woollen cloth. A straight edged piece of wood is laid on the glass $\frac{1}{16}$ in. from where the cut is to be, and the tool guided by the straight-edge is firmly and boldly drawn over the surface of the glass. It does not cut the glass, but scores a shallow groove in it, this being a line of low resistance the glass is easily broken there. If both sides of the glass are scored, the fracture will be much easier. After the cut is made a few gentle taps with a light hammer will cause the glass to crack along the groove. If a real diamond is used the process is the same. The diamond will cut best if held at one particular angle, and this must be found by trial on waste bits of glass. The cuts made with a diamond must not cross one another or will spoil the diamond. Note also that the glass must be an easy fit for the frame.

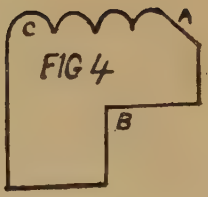
FRAMING WITHOUT MOULDING.

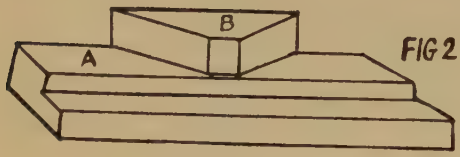
This is the easiest and cheapest way of framing pictures. The back of thick paste-board is fixed to the glass at front by paper or linen glued round the edges, and extending as far as desired in front to give the effect of a thin moulding. If then painted the result is very effective. The paste-board at back is as thick as a new penny for small pictures, thicker for large ones up to about 12 ins., which is the limit for such work. The glass is of equal size, and should be thin so that the back has less to carry. First, to provide for hanging up, make a slit with a knife in the back 1 in. below the top edge, draw through this some strong tape, the loop drawn through being used to hang the picture, the ends are spread V shape and carefully glued down and a bit of paper pasted over all to make a smooth surface. For larger pictures two loops must be provided. A strip of paper is saturated with good quality paste or glue and laid flat on the table, on this lay the picture, glass and back so that the strip is half covered. Turn the remainder of the strip on to the glass and smooth down, do the same with the other three sides, cutting the corners so as not to overlap. If this is carefully done the paper will adhere to the glass and back. When dry add other layers, the second one being calico, until $\frac{1}{8}$ in. thickness is built up. The edging can then be painted with enamel or covered with fancy paper. The picture must be hung vertically, not tilted.

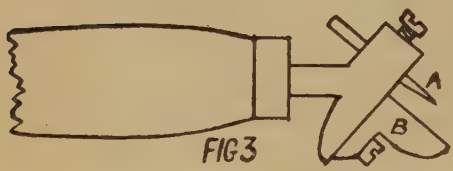
OVERMANTELS.

The Overmantels now so fashionable, having mirror in centre and a picture on each side, are really picture frames divided into three compartments. A frame of the desired size is made from broad moulding 3 to 4 inches wide. A mixed white and gold is more effective than all gold for this, the corners being screwed to ensure extra strength. To separate it into compartments choose a plain flat gold $1\frac{1}{2}$ inches wide. The rebate side must be used for the mirror, but another rebate must be cut at the other side to take the picture. The ends are cut away enough to allow the gilt surface to come level with the frame, the remainder being screwed and glued to the frame to strengthen and stiffen it.









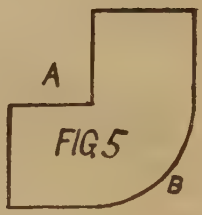


Fig. 1—Mitre Block. A and B are the diagonal cuts used for cutting moulding for a square joint. C is for cutting straight across. A Mitre Box is more effective, but is not so easy to make.

Fig. 2—Shooting Board for planing the ends cut by the saw. The mould is laid against the block B, allowing the end to project about $\frac{1}{8}$ in. The plane is laid on its side resting on the lower part of the board. In this diagram the block B is shown as one solid piece of wood, but a much easier way is to screw two pieces of wood $1\frac{1}{2}$ inch square to the lower block.

Fig. 3—Rebate Tool for cutting a rebate when making picture frame from plain wood. The guide B and the cutter A are both adjustable, so as to cut various sizes of rebates.

Fig. 4—Section of Moulding made from plain wood. A shows the edge chamfered off with a plane. B, the rebate cut with rebate tool or with rebate plane or saw. C, the beading or reeds cut with either hand beader or with beading planes.

Fig. 5—Spanish Corner. A being cut away to fit the corner of the frame. B is rounded and deeply grooved for the double cord to fit in to enable the frame to be compressed between four of the corners.

COPYRIGHT

How to Clean a Clock.

Adjusting and Small Repairs.

By M. COLE.

How a Clock Works. The pendulum measures the time, the spring or weight moves the hands through the train of wheels, and keeps the pendulum going. The clock stops and starts again at every swing of the pendulum, which, having stopped the clock when at its highest, falls by its own weight and on its way down unlocks the escape wheel, which through the pallets gives the pendulum a push or impulse, this with the momentum acquired in falling from the highest position on one side, enables it to travel to the highest on the other side, the whole cycle of movement is then repeated. In a Lever or Cylinder escapement clock the balance wheel and its spring do the work of a pendulum. The time a pendulum takes to swing from the highest on one side to the highest on the other depends on its length measured from the point of suspension to the centre of gravity, usually a little higher than the centre of the bob. Longer or shorter swing does not alter this, a pendulum about 40 inches long takes one second to swing, one a quarter the length takes half a second, and all other lengths in proportion. The pendulum rod is longer in hot weather and shorter in cold, so that a clock gains in winter and loses in summer, unless fitted with some form of compensated pendulum. The balance wheels of good watches are also compensated. Clocks with weights and long pendulums are the best timekeepers, as the weight gives constant pressure, while with a spring the pressure or pull varies. In the best clocks this is compensated by a *fuzee*. The spring does not act directly on the train of wheels as in the cheaper ones, but by means of a cord on a grooved cone, the pressure is always equal because the leverage is greatest when the spring is nearly run down, and least when the pull is most powerful. In the cheapest drum clocks the end of the main spring is fastened to part of the frame to save the expense of a barrel, in these the clock is stopped during the winding but with a barrel the pull on the wheels is constant from the outer end of the spring (which is fixed to the barrel) during the time the inner end is being wound up. In weight clocks there is a maintaining spring for this purpose.

CLEANING A SILENT PENDULUM CLOCK.

Remove the Pendulum. In the clocks known as *Vienna Regulators* (a wall clock in a long glass fronted case with weights and large pendulum bob) the pendulum is fitted to the back of the case and connected to the movement by a pin working in a slot in the rod, this may remain in its place. In some of the smaller clocks, especially those in brass drums known as *Tic-Tac*, the pendulum is a fixture to the pallet arbor, but in all others it is hung from a small spring passing through a slit and kept there by a small pin. In some clocks the bob is loose and can be unhooked. The wire can in these cases be left on until the movement is taken out. In Case (Grandfathers) Clocks and the best wall clocks, the pendulum can be easily lifted out of the slot, a small door is usually fitted to the side of the case for this purpose. In marble and other mantel clocks the top of the pendulum rod is a fork and hooks on to a pin in a bit of brass plate forming the lower part of a small suspension spring and is easily unhooked.

Take the Movement out of the Case. In Case Clocks the upper part of the case is removable, usually by sliding forward. The movement is sometimes screwed down, but often kept in place by its own weight. In many English wall clocks the movement is fastened to the dial, which is fastened to the wooden frame surrounding it. This is fastened to the case by four wooden pegs at the sides, when these are drawn the dial and movement can be lifted off. The pendulum having been removed, the clock may be laid on its back for this purpose. The dial with the movement is now unscrewed and placed on some suitable support, so that it does not rest on the pendulum fork, as that might strain or break the pivots. In marble and other mantel clocks, the movement is held in place by two screws passing through the frame of the back door, and the ends of two brass straps. Remove these and take out the movement, being careful not to injure it in doing so. If a striking, the gong must be unscrewed before the pendulum is removed. In this class of clock, it is best to remove both doors by knocking out the pins of the hinges. This must be done from below, using a nail rather thinner than the pin, first filing off the point. This will allow the bevel and door frames to be properly cleaned. In the Vienna Regulator the whole movement is supported on two brackets, and held in place by two screws with large heads, on removing these it can be taken off leaving the pendulum in place. In some small drum clocks having pendulums, the whole movement is kept in place by three or four screws which sometimes form also the feet and hanging ring. In some of the eight day French and Swiss clocks the whole movement, with fixed pendulum, is held in place by a couple of screws at the side of the front part.

Remove the Hands. In most cases a small pin holds the hands on the centre spindle (*arbor*), remove this and the small washer (*collet*) under it. It is advisable to tie this to the hand to prevent loss, but the pin need not be kept as it is easy to fit one. The minute hand can then be lifted off, under this is the hour hand which is usually fitted with a tube and is only friction tight on the cannon

below the dial, this is easily lifted with a knife blade. In old clocks the hour hand is held in place by a small screw instead of a tube. This as a rule has scarcely a trace of thread on it, if lost it may be replaced by a brass pin fitting tightly into the hole. In small clocks, especially the cheap ones, both the hands are only friction tight, but are often so tightly fitted as to require a strong pull to remove them, sometimes the collet is screwed on instead of being pinned.

Remove the Dial and Frame. In all the better clocks the dial is fixed to a shallow three or four legged frame, fastened by pins to the main frame of the clock, draw the pins with pliers out of the feet forming part of the frame, and it can then be lifted off. The dial itself need not be removed unless any repairs are needed, but if it is great care is needed with enamel dials, as they are held in place by copper wires soldered to the back of the dial. In the cheap drum clocks the dial is held by the ends of several projecting strips passing through small holes near the edge and bent a little.

Let Down the Spring. The clock should be allowed to run down when the pendulum is removed, but as there is not always time for this it is usual to let down the spring. There is a special tool for this, but it can be done with the winding key. The user must be prepared for a sudden jerk (when the prawl is lifted clear of the ratchet) which may twist the key out of his hand and probably break the spring, still with care there is no difficulty in letting down one tooth at the time. Where the spring is not enclosed in a barrel, instead of letting it down, it may be wound up and a clip of ¼-in. wire C shaped be put upon it.

Remove Pallets and Arbor. The pallets (the anchor shaped piece that controls the escape wheel) and the arbor carrying it should next be removed by unscrewing the cock, a small bracket screwed to the main plate. Great care is needed as the *pivots* or ends of the arbor are the smallest in the clock, often no thicker than a fine needle. The regulator will come away with this. It is a spindle passing through the top of the dial, and ending in a small wheel. Sometimes this wheel is outside the small bracket and falls off when it is removed, but in other makes it is inside the bracket and requires careful handling. The small spring on which the pendulum is hooked is also fixed to this part. In some small clocks the pendulum is a fixed part of this arbor, really an extension of the fork, but in these there is great danger of breaking or bending the pivots.

Remove the Motion Work. Under the dial some small wheels will be found. The central wheel of the clock has its spindle extended through the front of the dial and passes through both hands. The wheel carrying the minute hand is friction tight on this, and gears with a wheel and pinion running on a stud beside it, which gears with a wheel carrying the hour hand. All this is held either by a large headed screw or a bracket. Removing one screw will allow all these to be lifted off, though the minute wheel often needs a good pull to remove it.

Draw out the Pins so as to separate the plates, the bars connecting the two plates are rivetted to one of them, but pass through the other and are held by pins which are often so tight as to need a great deal of force to remove them. Strong pliers are used, and the

pins are usually too much battered to be used again. If they break in trying to remove them, file off all projecting parts and draw the plate over them, the part in the bar can be knocked out afterwards. Some frames are fastened together with screws, and others of the lowest quality by rivetting, in this case a part must be filed off to release the plate, but leaving enough to rivet down again. Lift off the plate and remove the wheels, notice that one of the wheels is under the barrel, which must be taken off to release it. If not accustomed to small work, there may be a little difficulty in re-placing the screws and small parts. The easiest way is to use the lid of a pasteboard box, lay it hollow side downwards, draw on the flat part a sketch of the clock frame and put each screw in a small hole in the position it will occupy in the clock. In the best makes of clocks the pivot holes of one side are not in the plate itself, but in small plates each screwed over a hole in the plate larger than the pivot hole. This is to allow of adjustment for depth. If these are removed each one must be marked so that it is put back in its proper place, but a beginner had better leave them in position.

Put the Small Parts in Petrol Jar to dissolve the oil and dirt. A pint basin with a plate to cover it to prevent evaporation will do for this, with a couple of saucers to put the parts into after cleaning. After soaking, lift out with a wire hook and clean with a soft old tooth brush. If the teeth of the wheels are very dirty, clean with a stiff brush, being careful not to bend them. Clean the pinions with a bit of wood. The plates should be cleaned with petrol, then with polishing paste. Last of all clean out the pivot holes, loosening the dirt with petrol, then use a bit of wood sharpened to a point fine enough to enter the smallest holes, then going on to the larger ones. Examine the pivots with a magnifying glass, and if rough polish with a strip of the special oilstone sold for the purpose, resting the pivot in a groove cut in a block of wood and turning it while rubbing with the oilstone.

Re-placing the wheels. There is only one place in which any of the wheels will fit properly, so although a little patience may be required, they cannot be put in the wrong places. Remember the centre wheel has a long spindle, the wheel of the barrel is the thickest and gears into the largest pinion, and the escape wheel goes at the top. When all are in place in the one plate, the other plate can then be put in position with the end of the bars through the holes. The next part is the most difficult, to get the pivots into their holes in the top plate. Use a bit of wood with a notch in the end to push with, and a wire hook for pulling, and they soon get there, but a good light is necessary for this. Make sure the points are free in the holes before pinning down with the trying pins. These are made of thick wire, tapered at one end and the other bent to a loop for handling, and are used to fasten the plates while trying the wheels before the final pinning down. To file the ends of wire taper, fasten a length in a pin vice, lay the end on block of wood having a groove about half the thickness of the wire, turn the wire towards you while using the file from you, cut off the length required for the permanent pins, insert in tbe hole and drive home with a small hammer, as it injures a clock to run with loose plates. Some workers use

copper or soft brass wire that fits easily in the hole, and then twist it to S shape, but these do not hold tightly. Pin the ratchet wheel to the winding square, and screw on the prawl with its spring, then put on the pallets with their arbor, and the bracket or cock with the regulator if there is one, but as this projects great care must be used or it will be bent. Replace the motion work and put on the dial with its frame.

Oiling the Pivots, &c. Special oil must be used for this, but if none can be had use Oil of Almonds for small work, and purified Sperm for large, but it should be frozen first, and the part that will not solidify by frost separated for use. Never use vegetable or mineral oils. Only a very small quantity is required for a pivot or other clock part, apply with a bit of thin wire flattened at the end. One drop is enough for a pivot hole, a little extra on the thick arbor that goes through the centre of the spring, both where it passes through the plates and also where it passes through the sides of the barrel as it turns there when winding up. The spring itself should be oiled after handling. Put a little on the pallets (but not if they are Ruby), but none on the wheels, and use great caution that none gets on the spindle that carries the minute hand in those clocks where it has a tapered tube, nor on the back of the wheel in those where it is carried round by the friction of a spring plate, and specially see that none gets where the hole in the plate presses on a shoulder on the central spindle, or it will not carry the hands round. See that the pivot of the arbor carrying the pallets is oiled before the bracket is screwed on as the hole is difficult to get at later. In a striking clock a little oil should be put in the pinion of the fan, as it has to run at a high speed.

Adjusting. Before putting on the dial, the movement must be examined and adjusted. Make a temporary stand of wood to hold the movement with room for the pendulum to swing, see that all pivots move freely in their holes but allow a little end shake, and see the pallets do not drop too far between the teeth of the escape wheel, only enough to ensure its being stopped at each swing. The drop must be as little, and the impulse (or sliding pressure of the surface of the tooth on the surface of the pallet) as much as possible. If too deep the teeth will not pass. In a good clock this can be regulated by the cock of pallet arbor, in cheap American clocks the pallets are on a pin which passes through two loops at the back of the pallet piece and is carried by an adjustable bracket, so is easy to regulate. In these a wire extended from the pallet piece is brought down and forms a loop through which the pendulum rod passes. Any bent wheels must be straightened, but some wheels are purposely dished so as to work into an unworn part of the pinion. This is sometimes done with the escape wheel to get it to work into an unworn part of the pallets, but usually the pallet piece can be moved on its arbor. If the wheels gear too deeply there is too much friction, if not deep enough they may slip or jam between two teeth and stop. There is always some provision for adjusting the position of the pallet arbor, often the screw hole in the cock is enlarged and can be filed deeper if needed. The crutch is really a short pendulum and its sway is often limited by two pins in the plate, see that it swings without

touching either of them, bending it if needed. The clock being wound up it should run with an even sound, adjust the crutch until it does so. The best clocks have provision for doing this without bending the crutch, some of them are supposed to be self-adjusting, the pallet piece being only spring tight on the arbor and gets into the right position by the weight of the pendulum, but it does not always do so. Jewelled or Ruby pallets require great care in handling, as they are only cemented into their holes; these must not be oiled. When putting on the hands of a striking clock, see the minute hand is in correct place, as there are four possible positions for it or its arbor, but only one of them correct. The hour hand in most clocks being only spring tight can be moved as required. It is advisable to file a small nick across the little washer or collet that goes over the hands and under the pin. In clocks where a friction plate is used to carry the hands round, some pressure is needed to hold them down while inserting the pin. The hole is very small and sometimes difficult to find, note before the hands go on what figure it points to. After running the clock without pendulum, put it on and see it is beat without touching the limit pins. See the sliding piece of the regulator in the cock bracket is set so that it can be moved either up or down by turning the end of the spindle that runs through the front of the dial, then regulate by the pendulum bob until it goes within two minutes a day, after that it can be completed when in the case. When taking the clock to pieces, a mark should be put on the stem and bob of the pendulum so that it may be replaced just the length it was before, so saving time in regulating the pendulum.

ESCAPEMENT CLOCKS.

Difference between Lever and Pendulum. Lever and cylinder escapement clocks are really large watches, the pendulum being replaced by balance wheel and spring. In lever clocks the pallets, which are the same shape as in a pendulum clock, have on the same arbor a lever one end of which is forked, usually with four prongs forming three slots, the centre one being used by a pin in the balance wheel near the arbor, the outer prongs are to prevent the lever getting too far on either side. The arbor of the balance wheel is usually pointed at both ends, the points each resting in a cup formed in steel screw, which allows adjustment. The balance spring is fastened one end to a collet fixed to the arbor of the wheel, the other end pinned in a hole in a convenient part of the frame. The forked end of the lever is balanced by a piece extended to the other side, and is used for adjusting its position on the arbor. If this is joined to a wire bent to a suitable shape to clear the frame, and the balance wheel and its spring removed, the clock is converted to a pendulum clock. In a balance escapement, the impulse given through the pallets coils the spring, which uncoils again when allowed, just as a pendulum falls from the highest point of its swing. When cleaning such a clock, first pull out the pin fastening the end of the balance spring, then it can be taken down like any other. When putting together again, the pallets (which are usually pins) must be equal distances from the arbor of the escape wheel, the pin of the balance

wheel in the centre fork, and the balance spring at rest without tension either way. As the lever is only friction tight, it is easy to make this adjustment. In these clocks the friction plate to connect the centre wheel to the hands is inside the frame instead of under the motion wheels.

Carriage Clocks with Cylinder Escapement. Most square carriage clocks and some drum clocks have cylinder escapements like what used to be known as Geneva watches. The main objection to this form being the very fragile nature of the teeth of the escape wheel owing to their shape, each tooth leaf-shaped and raised on a stem above the level of the wheel itself, these are controlled by a cylinder or short tube, part of which is cut away. The action is easily understood from the diagrams. Many of these are jewelled, the pivot holes being in plates of glass inserted where the pivot holes would otherwise be, and other plates not pierced at the end (end stones). The whole escapement is mounted on a flat plate or table secured by four screws and easily removed. The pinion of this gears into a crown wheel having teeth on the sides of the edge. In putting together, great care is needed not to get these either too deep or not deep enough. To take down a square case carriage clock, first unscrew the plate under the base held by one screw, this will allow four others to be removed, the base then comes away and the case is ready to fall to pieces. The door is quite loose and may fall out if not carefully removed. The movement is now held only by two screws to the base. The escapement of these clocks is small and delicate, the parts being only the size of those used in large watches. If this is to be cleaned without taking to pieces, the whole table may be put into the jar of petrol and rinsed several times until the old oil is washed out. If taken to pieces first unpin the balance spring and measure how far it is through the hole, so as to replace in the same position again. When putting together again after pinning, there must be no tension on the spring either way when the cylinder is equally on both sides of the tooth it encloses.

STRIKING CLOCKS.

There are two classes of these, the best being known as Repeaters, having a rack and a revolving prawl working on it. The number of teeth of the rack in use is controlled by a cam on the hour wheel on which a lever rests, the thickest part of this cam is in use at one o'clock, the thinnest part at twelve, then allowing 12 teeth to be in use. This sort will repeat the number last struck as often as the lever is lifted. In the other sort a locking plate or wheel having parts of its edge cut away is used, a bent wire resting on the edge of this is raised at each stroke to fall again when the bell is struck, but if it fall in one of the gaps the striking part is locked until it is released again at the next hour or half-hour. This wheel travels a little after each stroke. In both sorts a fly occupies the same position that the escape wheel does in the going part to prevent striking too quickly. The only connection between the time part and the striking part is by a pin usually on the under side of the minute wheel, which gradually lifts a lever then drops it suddenly at the hour.

A striking clock is practically two almost similar movements side by side in the same frame, and should not be attempted until the worker has had plenty of practice with the finer makes of silent clocks. The main difficulty is that there are so many pivots to be got into position at the same time. When the lever has been raised to a certain height, the striking train is started or *warned*, but is soon stopped again by a pin on one of the wheels striking against the end of an arm. When the end of the lever falls off the pin in the minute wheel at the hour, the arm moves out of the way and allows the movement to run until the striking is completed. The cheaper forms of clocks with locking plates are easiest to do.

SMALL REPAIRS, &c.

New Pins in Dial are sometimes needed, scrape away the enamel round where the old pin was, clean the surface of the metal, hold a bit of copper wire with pliers in position, put a drop of soldering fluid on the joint, and solder with small copper bit. Do not use blow-pipe or the enamel in front of the dial may be cracked.

Collets for Winding Holes are usually of thin steel and are easily fitted by bending the fangs on the under side of the dial, but in clocks having sunk centres to the dial they are of turned brass, and are held by a U shaped piece fitting in a groove at the back of the dial. If required to fit these without taking off the dial use tube glue, then carefully adjust so that the winding square is in the middle of the hole.

New Ruby Pallets. These are mostly used in visible escapements, and are fitted with shellac, but tube glue will do as well.

Worn Pallets are often caused by want of oil or by dust getting on the oiled surfaces. Although the pallets are of hard steel, they wear more than the softer brass of the wheel teeth, but as both wear away there is often too much play to be corrected by lowering the pallets. If the pallets can be moved so as to get an unworn part of them into use, this is usually enough, but if not they must be re-shaped. Soften the steel by heating it to redness and cool as slowly as possible. (This is best done between two pieces of fire-brick made red hot). Then with fine file and oilstone to follow, correct the shape, then harden by re-heating to red and quickly quench in water. Some workers prefer to temper the steel as it allows a little file work afterwards. Some shapes of anchor pallets must be closed a little to make up for the amount worn or filed away. This is done by squeezing while soft in a vice, making a careful measurement before bending. The wheel must also have attention as some of the teeth may be worn at the tips more than others. Make a gauge from sheet metal U shaped, with the ends turned over to form hooks, to hook on the arbor each side of the wheel, also a piece to clip across but able to slide up and down. This is easily made and quite as useful as a bought tool.

Noisy Clock. The usual causes are : 1—Wooden case resting on wooden mantel board : 2—Crutch knocking against pins : 3—Pendulum rod loose in the fork : 4—Pallets fit too loose in escape wheel.

Suspension Spring twisted or broken through careless handling of clock; this must be replaced by a new one.

Broken Marble Case is best repaired by giving each surface a coat of ordinary oil paint, put together and allow time to set. Tube glue is quicker but does not make so strong a joint. If parts that are held by wires are loose, use a good quality Plaster of Paris mixed with water to a thin paste; wet the parts it is to be applied to before using it.

Winding Square out of Shape from using a key too large for it. This should be filed to shape again and fitted with key.

Regulator Teeth are often stripped off through trying to screw it down after it has reached its limit. Replace with new parts, which are very cheap.

Broken Hand is seldom worth repairing, but if a new one cannot be had, solder a bit of wire under the broken part, file up and varnish with spirit varnish with a little blue paint in it.

Damaged Enamel Dial. A special paste is made for filling these and is easily used. It is softened by heat and applied with a knife blade to the broken part.

Worn Pivot Holes. The wear of a clock is shown in the enlargement of the pivot holes, which are also out of shape. The hole must be plugged and a fresh one drilled. Select a piece of bush rod (a special kind of brass tube) having a hole smaller than the pivot hole is to be, file the end so as to taper it a little so that it will go not quite through the plate by pushing it. Cut off length with a fret saw, put in the hole and drive in with a tap of the hammer. A piece of tube should be under the plate to prevent its being bent when driving the plug in. This will hold firmly enough for the purpose. Dress off superfluous metal, then open the hole to the size of the pivot with a broach. The outer side of the hole must be counter-sunk with a large drill to make a cup for the oil. If no bush rod can be had, plain brass rod can be used. In this case, first with a straight edge and needle point mark two lines to cross exactly where the centre of the new hole is to be. Plug with brass rod, then after trimming off both surfaces, mark those parts of the lines that are missing so as to find centre of pivot hole. Mark with centre punch, and drill the hole smaller than required, open out with broach and counter-sink for oil.

Broken Main Spring. The spring itself is seldom broken, but the hole at the end is often torn by over winding, in this case a new hole must be made. Remove the spring from the barrel by pulling out the arbor with hand vice or pincers, see that it does not jump away. The lid of the barrel can be prized off, but if too tight hold barrel in left hand, lid down, and give a smart tap with hammer on pivot. Soften one end of the spring by holding it in a gas flame until red hot, and allow to cool slowly. The flame of an incandescent burner, with the mantle removed, is very suitable for this, as it will

not blacken the spring. Drill a small hole the same distance from the end the old one was, and open it out with a broach and file to D shape, the flat part being nearest the end of the spring, but avoid sharp corners to the hole. To insert the spring in the barrel, first bend the end to the same curve as the barrel, insert the end and hold it with the thumb of left hand, then with the right thumb press down the spring at the other side of the barrel, and continue so as to get that part of the spring inside the end that is already in the barrel. The remainder is comparatively easy until nearly all is in, the last part can be put in by grasping the square of the arbor with hand-vice or by putting on the key and turning it.

Clock striking before or after the hour is usually caused by the pin in the motion work that lifts the lever being bent. Adjust so that the lever falls exactly at the hour, or if needed lengthen the point of the lever. If the lever is bent back, it will miss the pin altogether and the clock will not strike. If the bell is loose, the sound will not be clear. The hammer, when at rest, must not touch the bell. The sound is also modified by the part of the bell the hammer strikes, it should be near the edge.

Clock striking too quickly is sometimes caused by the small spring in the fan being bent or lost. Replace by a bit of thin watch spring. If still too quick enlarge the fan with a bit of card.

Escape Wheel Teeth bent or broken. If broken, a new tooth must be inserted : if bent, carefully bring it back to shape and see that all teeth are of equal length. In some forms of escapement the tips of the teeth do a lot of work, in others they do nothing.

Blackening Figures in Brass Dial. Use the black enamel sold for cycles, paint thinly, and when dry repeat until thick enough, or powder some sealing wax of good quality the required color, and fill the hollows with it. Then apply heat to the under side of the dial to melt the wax, and trim off with a knife.

New Teeth in Wheel. Cut away part of the rim of the wheel, (as shown in the diagram), and insert a piece of sheet brass of the same thickness but larger at the rim, see that it is a good fit and solder with soft solder. Cramp a bit of sheet zinc the thickness of a worn sixpence to a part of the wheel where the teeth are still good. If to replace one tooth, file for three teeth, remove this and transfer to where the tooth is missing, cramp on and file the brass to the zinc template. When several teeth are to be replaced, make the template V shaped, cut away a little at the point and file a hollow to fit the arbor, then cramp on and file to shape as directed above. When several teeth have to be replaced, it is easier to solder the piece of sheet brass on to the wheel instead of inserting it. It does not look nice but answers quite as well.

New Hook in Barrel. In some clocks a V shaped piece is formed by two cuts in the barrel, the point projecting inside the hole, the spring being hooked on to this, but in most cases a rivet is used. When renewing this, if the hole is out of shape drill a fresh one and

file square. Cut a piece of iron to fit the hole, the inside to form the hook. and allowing at least $\frac{1}{8}$ in. to project through the barrel on the outside. Put the barrel on a suitable support, and rivet on with a light hammer. Avoid sharp corners to that part of the hook that will touch the flat of the hole in the spring. If properly shaped, the hook will slip into the hole when the spring is wound.

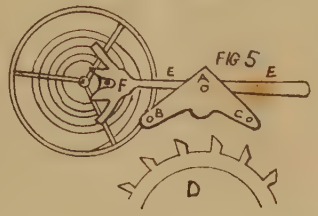
Broken Pivots of wheel arbors are difficult to replace and need proper tools for the job, but the pivots of the pallet arbor can be done with few tools. File a flat on the upper surface of the arbor and cut a V groove in it, select a sewing needle of the right thickness, fasten it down on the groove with wire and solder with soft solder. Clean carefully afterwards so that no trace of the soldering fluid remains as it would rust the parts, then oil it well. It is not a job to be proud of, but it will work.

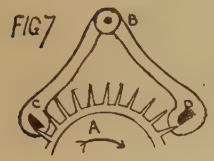
Dust in Case. Dust will spoil any clock, and many cases are not dust proof. The cheap lever clocks are the worst of all. In the best mantel clocks there is a strip of zinc bent round to enclose the movement. If this is missing it may be replaced by a strip of cardboard. Large case clocks are all the better for some thick paper arranged to enclose the movement as far as possible. A small hole will admit a lot of dust.

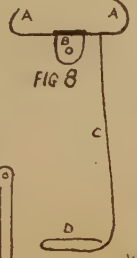
Altering Lever Clock to Pendulum. To do this it is only necessary to solder a piece of wire to the counterpoise of the lever, and remove the balance wheel. The wire, before putting on, must be bent to such shape that it will clear the fixed parts of the frame, and will hang down, it can afterwards be regulated in shape as required to get it in beat. The wire should be about the thickness of a stout pin. Use a glass bead for the bob with a bit of cork having a hole in it to keep it in position. If a drum clock, part of the drum must be cut away for this, or it can be hung on a wall.

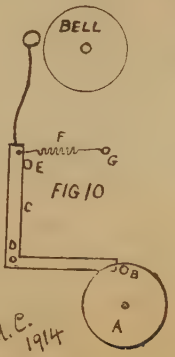
Altering Silent Clock to strike once at the hour. Put a pin in the minute wheel and fix on the plate frame an L shaped lever pivoted at the angle so that the lower limb rests on the pin in the wheel and is gradually raised as it turns, but falls off the pin at the hour. Put a stud in the frame to the right of the upper limb to limit its movement, also a spring from the upper limb to bring it up to the stud when free from the pin in the wheel. A wire is extended beyond the upper limb with a knob at the end to strike the bell on the rebound. All must be very lightly built so as not to put too much extra work on the movement.

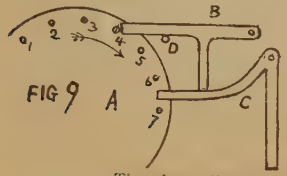
A Few Dates. Earliest clock known in England, 1174. First clock made in England, Glastonbury Abbey (striking hours, using locking plate) 1340 or 1350. Earliest spring clock or watch, 1500. Fuzee invented, 1525. Pendulum discovered (Galileo) 1582. First applied to clocks, 1657. Balance spring to verge escapement, 1658. Rack motion striking clock, 1660. Concentric minute and hour hands, 1671. Anchor escapement, 1680. Cylinder escapement, 1695. Jewels in pivots, 1704. Lever escapement, 1765.











The above diagrams are not drawn to scale.

Fig. 1. Cylinder Escapement. *a*—cylinder between two teeth locking the wheel. *b*—it has made a quarter-turn forward allowing a tooth to enter it and lock the wheel. *c*—the cylinder has moved backwards a little, but the wheel is still locked. *d*—cylinder a little further back and wheel unlocked ready to move. *e*—wheel has moved and is stopped by back of cylinder.

Fig. 2. Old fashioned Tic-tac French escapement.

Fig. 3. Usual form of Anchor escapement.

Fig. 4. Pallets in best French clocks. The square hole allows adjustment on arbor, which is square at that part.

Fig. 5. Lever escapement (the wheel *d* is shown lower than correct position for clearness). *a*—arbor of pallet piece, which also passes through the lever. *b* & *c*—are pallets (usually pins) projecting from the face. *e*, *f*—lever forked at the end showing pin on collet of balance wheel in the middle fork.

Fig. 6. How new teeth are inserted in wheel.

Fig. 7. Usual form of visible escapement with Ruby pallets *c* & *d*, which are semi-circular in section.

Fig. 8. Pallets of common clock of sheet steel. *aa*—pallets. *b*—brass bracket with pivot holes to fit pin carried by adjustable bracket. *c*—wire crutch with loop *d*, through which the pendulum passes. This wire is bent when the pallets are at the side of the wheel.

Fig. 9. Modified form of old style escapement suitable for a large clock one of the few that is easy to make. *b* & *c* are levers working on pivots near their ends, the lower one is connected to the pendulum by a fork not shown. *a* is wheel having 20, 30, or 60 projecting pins, number according to the length of pendulum and train used. When the pendulum swings to left, the two levers rise and pin number 4 passes the end of lever and wheel turns, 6 then presses on bent lever *c*, giving the impulse to pendulum which swings to right, releasing 6 and allowing 3 to again stop the wheel by striking end of lever *b*.

Fig. 10. Silent clock altered to strike once at the hour. *b*—pin under the minute wheel *a* has just released the end of lever.